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A New Test of the Rate of Setting Cement (illustrated)—Notes and Queries .

THE COMPLETION OF THE CHICAGO DRAINAGE Canal requires the expenditure of $3,685,648 more than the $28,258,748 now provided for, according to a majority report of the Finance Committee of the Board of Trustees recently made public. This additional amount brings the cost of the canal completed ready for use up to $31,444,397. A minority report of the same committee places the required sum to finish the work at $1,396,191, and with the present state of factional ill feeling in the Board of Trustees considerable acrimonious duscussion has resulted. The majority faction has, however, accepted the minority committee report, and a bill is now being prepared to be submitted to the State Legislature of Illinois, which amends the act of 1895 so that the present tax levy of 1½% for the construction work of the canal shall continue until 1899, instead of terminating now. The passage of this amendment will, it is believed, be sufficient to provide the $3,685,000, needed to complete the work. It is also the intention of the Board of Trustees to present to the legislature two other bills, one giving to the board the right to use any part of the waterway of the Illinois & Michigan Canal controlled by the state, providing said waterway is left in the condition it is found in; the other, giving to the board the right to condemn water power now existing, but which later may conflict with the needs of the sanitary district.

THE WIDENING OF THE CUYAHOGA RIVER at Cleveland, O., is to be carried into effect, and steps have been taken to secure the necessary land. The Lake Shore Ry. has agreed to transfer the land to the city, and will build a new fixed bridge, the city withdrawing its demand for a drawbridge.

A COMPENSATION RESERVOIR AT FITCHBURG, Mass., is to be maintained by the city in the interest of a large number of mill owners on the Nashua River, who, in return, relinquish water rights in two ponds taken for the city water supply in 1892. Compensating reservoirs are quite common in England, but have seldom been established here, cash payment generally being made for water damages.

SPECIFICATIONS FOR A NEW WATER SUPPLY FOR Hoboken, N. J., are to be prepared in accordance with a vote of the water commissioners on Jan. 5. The specifications will be (1) for water delivered at the city mains and (2) for an "independent supply," which may be variously interpreted but probably means for a supply to be owned by the city. Mr. Thos. H. McCann, of Hoboken, was appointed Engineer. Hoboken owns its distributing system, but water is supplied by the Hackensack Water Co., under a contract about to expire.

THE JERSEY CITY WATER AWARD has been concurred in by the Board of Finance, but before the proposed contract with the East Jersey Water Co. can be executed the Mayor must approve the award. It is expected that he will not act until the last day allowed him by law, Jan. 9. Meanwhile the Jersey City Board of Trade has employed Mr. Geo. W. Rafter, M. Am. Soc. C. E., to report as to whether the contract would be likely to prove advantageous to the city.

A STAND FOR LIMITED MUNICIPAL FRANCHISES is made by Mayor Wurster, of Brooklyn, in his annual message for 1897. He states that franchises now in existence have been granted in perpetuity, and urges a change, together with a greater revenue from the companies enjoying these valuable privileges.

MUNICIPAL OWNERSHIP OF GAS PLANTS in Great Britain and Ireland is said by the London "Contract Journal" to prevail in 203 municipalities, while there are 437 private companies. The ownership by countries is given as follows:

	England and Wales.	Scotland.	Ireland.
Municipal	160	36	7
Private	426	2	9

The same journal gives the paid up capital of the companies as about $225,000,000, and the sums borrowed by the municipalities as about $125,000,000. The total amount of coal used is given as 11,937,446 gross tons, with an output of 121,422,000,000 cu. ft. of gas, of which 111,000,000,000 was sold during the year ending March 25, 1896. The mileage of mains on the date named was 23,857, supplying 2,659,771 consumers' premises and 526,888 public lamps. The gross yearly receipts of the companies is given as about $60,000,000, and of the public plants at $30,000,000, with respective expenditures of about $45,000,000 and $20,000,000.

THE BOSTON SUBWAY lease to the West End Street Ry. Co. has been approved by the Railroad Commissioners. The lease is for 20 years, on the basis of 4⅞% interest per annum on $7,000,000, or a similar percentage of the net cost of the subway, if that cost is less than $7,000,000. The company also agrees, after it shall have acquired the use of the subway, to pay each year such additional compensation, if any, as may be determined by a computation of the number of passages made by cars in and through the subway, in case the amount so computed exceeds the amount determined by the percentage of the net cost of construction.

THE UNDERGROUND ELECTRIC CONDUIT SYSTEM has been adopted by the Metropolitan Street Ry. Co., of New York, to replace horse traction on the Fourth, Sixth and Eighth Ave. lines. Compressed air cars were also considered, but the electric system has been finally adopted.

THE CYLINDRICAL CAR is in evidence again, this time on the electric railway at Concord, N. H. It is also a convertible car, built on the principle of a rolling top desk, the side panels sliding up grooved posts into the roof to form an open-sided summer car. In case of a rainstorm or sudden change of weather the sides can be promptly rolled down. There are transverse seats and a central gangway.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was caused by a landslide on the Missouri Pacific Ry., near Holden, Mo., Jan. 3. A freight train ran into the obstruction and three men were killed in the wreck.—On Jan. 5 the rear car of a train on the Carson branch of the Chicago, Burlington & Quincy R. R. left the track on a trestle near Carson, Ia., and fell from the structure. Six persons were hurt, some very seriously. On Dec. 30, while a train of five cars was being switched to the trestle connecting the upper and lower yards of the Baltimore & Ohio R. R. at Pittsburg, Pa., one of the cars jumped the track at a street crossing and went over the trestle, taking two other cars with it. One man was killed and another injured.

A REAR COLLISION OF CABLE CARS occurred on the Lexington Ave. line, New York city, Jan. 5. A broken strand of the cable caught in the grip of a car at 81st St., and caused it to collide with the car ahead, the two cars then striking a third car. The cars ran to 96th St. before the alarm could be given to stop the cable. Six persons were injured, but none very seriously.

A FIRE IN THE DYNAMO ROOM of the People's Electric Light & Power Co., at Newark, N. J., on Dec. 29, caused a loss of about $135,000 and cut off the electric lights supplied by the company to Newark, Harrison, Kearney, Irvington, South Orange and other towns in the vicinity. The fire began at the switchboard, the back of which was of wood, and quickly reached the floor, which was saturated with oil. The company had a few days before declared a stock dividend of $250,000. It is a consolidation of several smaller companies, owning plants in different cities and towns. These plants were called on to supply the current which was stopped by the fire in the plant in Newark, but were able to furnish only a portion of what was required. New dynamos have been ordered and in a few days they will be set up in place of the ones destroyed by the fire. The fire should be a lesson to other electric lighting companies to build their central stations entirely fireproof, and to take especial precautions to protect switchboards.

THE RAILWAY WITH SUBMERGED TRACK, along the beach at Brighton, England, noted in our issue of Dec. 24, was badly damaged by a severe storm soon after its opening. Part of a pier near by was washed away and the piles and timbers battered the track out of shape and wrecked the car and its trestle frame.

THE NEWTOWN CREEK DRAWBRIDGE plans, as modified to meet the requirements of the War Department, have been submitted by Mr. J. J. McLaughlin, M. Am. Soc. C. E., the engineer, to the joint committee, and have been approved by the committee. The competitive plans have already been presented in our columns, and the modified plans call for a structure 180 ft. long, with a clear span of 150 ft.; width, 60 ft.; height of portals, 15 ft.; height from roadway to tops of cable towers, 94 ft.

A NEW SUSQUEHANNA RIVER BRIDGE is to be built by the Pennsylvania R. R. between Columbia and Wrightsville, Pa., to replace the one destroyed by a cyclone in October, 1896. It will be a double deck Pratt truss structure, with 27 spans of 195 ft., having a highway carried by the top chords and the railway carried by the bottom chords. The estimated cost is $450,000, and proposals will be received until Jan. 15. Mr. Wm. H. Brown, M. Am. Soc. C. E., Chief Engineer of the Pennsylvania R. R., will have supervision of the work.

THE BALTIMORE & OHIO R. R. SHOPS at Mount Clare (Baltimore), Md., are to be partly remodeled, and one of the large shops, 72 × 400 ft., will be transformed into a great locomotive repair shop. It will be equipped with a powerful electric traveling crane.

SINGLE-DRIVER EXPRESS LOCOMOTIVES are regarded with favor on several English railways, and the London & Northwestern Ry. is now rebuilding the engines of a class first introduced in 1862, having a single pair each of leading, driving and trailing wheels, and outside cylinders. The remarkably successful performance of these engines in the fastest express train service has induced Mr. F. W. Webb, Chief Mechanical Engineer, to thus extend their life. The leading dimensions are as follows:

Driving wheels	7 ft. 9 ins.
Leading and trailing wheels	3 " 6 "
Wheelbase	15 " 5 "
Driving axle journals	7½ × 8 "
Weight on driving wheels	31,360 lbs.
Weight, total	70,224 "
Cylinders	16 × 24 ins.
Boiler, diameter	4 ft. 0 ins.
Boiler pressure	150 lbs.
Tubes, 198; diam. (out.), 1⅞ ins; length	10 ft. 1 in.
Firebox (inside)	4 ft. 10 ins. × 3 ft. 6 ins.
Grate area	17.0 sq. ft.
Heating surface, tubes	980.0 " "
" " firebox	94.6 " "
" " total	1,074.6 " "
Exhaust nozzle	4⅝ ins.

THE CAHABA RIVER BRIDGE DISASTER.

We give herewith two views of the recent serious train wreck near Birmingham, Ala., in which a derailed train caused the collapse of the bridge carrying the Birmingham Mineral R. R. over the Cahaba River. The accident, as noted in our issue of Dec. 31, occurred on Dec. 27, and is

THE CAHABA RIVER BRIDGE DISASTER ON THE BIRMINGHAM MINERAL RAILROAD, DEC. 27, 1896.

thought to have been due to the removal or loosening of a rail by train wreckers. The bridge is said to have been 800 ft. long, with a central deck truss span of 150 ft. on masonry piers. The approaches were steel trestles with plate girder spans of 30 and 60 ft., and a short piece of wooden trestle connected each approach with the earthwork. The 150-ft. span, two 60-ft. girders and one 30-ft. girder span went down. The bridge was built four or five years ago. We have no information as to the style of floor used, or the form of guard rail, but it would, of course, be easy for train-wreckers to remove guard rails as well as track rails, though a well built bridge floor should be able to withstand ordinary derailments. We are indebted to the Birmingham Bridge & Construction Co., of Birmingham, Ala., for the photographs from which our views are prepared.

Reference may be made here to the somewhat similar disaster which happened Aug. 9, 1894, near Lincoln, Neb., on the Chicago, Rock Island & Pacific Ry., and was described and illustrated in our issue of Sept. 6, 1894. In this case a rail on a timber trestle was displaced by wreckers. The derailed train caused the collapse of a part of the structure and 11 persons were killed. The floor had outside guard timbers but no inside guard rails.

THE MANUFACTURE OF SLAG-CEMENT IN FRANCE.

In a recent number the "Nouvelles Annales de la Construction" describes the manufacture of slag-cement as practiced at one of the latest manufactories of this article, that of Vitry-le-Francois. The manufacture of this cement includes two distinct operations, the making of the slag-sand and its mixture with the lime.

The slag employed comes from the furnaces of Pont-a-Mousson and is well adapted for this purpose; it has about the following mean composition:

Alumina	22
Silex	32
Lime	42
Oxide of iron, magnesia, etc.	4
	100

Black slag, or slag containing a considerable per cent. of metallic oxides, is not suitable for this use. As to its physical state, that slag is best which has been chilled, or cooled most rapidly in contact with the air; and the silico-aluminate forming the slag should not contain an excess of lime, for then it would float and be expelled from the furnace before a sufficient degree of heat had been attained to develop the qualities forming cement.

To produce the quick chill required, a stream of water under pressure is brought in contact with the flowing slag, as near to the outlet as possible, and the slag is thus deposited in a granulated form in a masonry tank provided for this purpose. The sand thus made is taken away at each pouring, rejecting that sand made at the beginning and the end of each operation. When the sand arrives at Vitry it contains about 9% of water and must be dried. This is done by spreading it out upon sheet-iron dryers, which are passed slowly through a heating chamber. The sand is submitted to a temperature of 600 to 700° C., and upon leaving the chamber has a temperature of about 150° C. The slag is next turned into small iron cars and lifted by a chain carrier to the top of the building, where it is to be ground, the sand being first deposited in a mechanical sieve, which separates the scoria and other foreign bodies. From this sieve the sand is run into six grinding mills of different types.

After being ground the fine slag is carried by a chain of buckets to a bolting machine; this latter operation is performed with great care, and the product is a grey flour, extremely fine and unctuous to the touch. This is now mixed with lime in proportions previously determined.

The mixing is done in five special mixers, made up of a steel cylinder revolving on a horizontal axis, and each containing 1,600 kilos. of cast-iron balls. The product is 1,100 kilos. of cement in 80 working minutes. To obtain absolute and constant proportions between the slag-flour and the lime, the workmen charged with weighing the two materials are paid by the hour, so that they may have no interest in falsifying the weights; and in order that the time of mixing may always be the same, a mechanical counter is attached to the mixer, which makes fraud or mistakes impossible. When the cement leaves the mixer it passes into an iron bin, and from a bottom opening in this bin it flows into bags. The lime used is made at Vitry and the degree of hydraulicity is maintained between 0.32 and 0.35.

At the same establishment brick and pipes are made of the slag cement. The bricks are made by mixing 60 litres of lime with 250 to 300 litres of slag-sand. This mixture is moistened with a sufficient quantity of water to make a firm paste, and this paste is then molded in hand or steam brick presses. So-called facing brick is made of a mixture of this cement and silicious sand. The slag-brick are especially useful for foundations or basement work, and they are also employed for paving courts and for cheap construction. Pipes are made with slag-cement and a silicious sand from the Moselle; 500 kilos. of cement are used to 1 cu. m. of sand. The stiff mortar from this mixture is forced into steel molds by iron rammers. The mold is removed as soon as the ramming is finished, and after drying for three days the pipes are immersed in a tank of water for 24 hours. They are then stacked up in the yard of the factory for three or four months before delivery for use. These pipes harden with moisture, and impart no taste to water passing through them. Tests made of this Vitry slag-cement show a resistance reaching 45 kilos. per sq. cm., or 696.8 lbs. per sq. inch, at the end of one year.

NEAR VIEW OF CAHABA RIVER BRIDGE WRECK, SHOWING DAMAGED PIER.

THE ST. LAWRENCE BRIDGE COMPETITION.

(With two-page engraving.)

On Jan. 24, 1895, the Montreal Bridge Company, through its consulting engineer, Mr. Walter Shanly, M. Can. Soc. C. E., invited engineers and bridge builders to send in plans and estimates for the steel superstructure of a proposed bridge across the St. Lawrence River, at Montreal. It was specified that this bridge should have one "cantilever span" of 1,250 ft., two side spans of 500 ft. each, 15 viaduct spans, on the south approach, of 250 ft. each, and 18 viaduct spans, on the Montreal side, of 240 to 60 ft. each, the clear headway in the channel span to be 150 ft. This bridge was to be designed for a double-track steam railway, two lines of rails for electric street car service, a highway for ordinary vehicles, and two footways. On the cantilever spans all the roadways were to be on the same level; but on the approach viaducts the four railway tracks were to be on top, with the highway and footways below them, with connections of easy grade. The piers of the cantilever spans were to be wholly of masonry and those for the approach spans were to be of masonry to a point 15 ft above high water, and of steel above that level. A prize of $1,000 was offered for the acepted plan, and one of $500 for the "next best," with the possibility expressed that the designer of the accepted plan would be also "employed in the construction of the bridge."

In response to this invitation a large number of plans and estimates were submitted by engineers from the United States, Canada, England and Belgium, and by the courtesy of the Montreal Bridge Company, we are enabled to present these plans, on an inset sheet this week, together with such description in each case as space will permit. On Aug. 8, 1896, the bridge company announced, through its Managing Director, Mr. C. N. Armstrong, that Mr. Walter Shanly, C. E., to whom all plans had been submitted, had, after an exhaustive examination, awarded the first prize to Mr. Edward S. Shaw, C. E., of Boston, Mass., and the second prize to Mr. A. L. Bowman, Assoc. M. Am. Soc. C. E., of East Hartford, Conn. Special attention was also called by Mr. Shanly to the plan submitted by Mr. J. W. Balet, C. E., of New York, which, while possessing peculiar merit, did not comply with the conditions of the advertisement, and could not be considered in awarding the prizes. The bridge company, upon this recommendation, awarded a special prize to Mr. Balet.

We preface the description of the various designs by noting that in the preparation of our inset sheet tracings were made from the original designs and these have been reduced by photography to a uniform scale, so that the several designs may be better compared. The space at our disposal forbids any very detailed description; but the effort is made to give enough in each case to indicate the special features and the claims made for excellence, together with aggregate weights and cost.

Design by Edward S. Shaw.

Fig. 1 shows the first-prize plan of Mr. Edward S. Shaw, of Boston, Mass. In his plan the main channel span of 1,250 ft., measured from center to to center of piers, is made up of two cantilever arms of 450 ft. and a center span of 350 ft.; the shore arms are 600 ft. long each. Four trusses are used, and as the bridge is 80 ft. wide, the trusses are made vertical throughout, with evident advantage in simplicity of design of details of transverse connections, and a consequent saving in labor in manufacture and erection. In the main piers of the cantilever span, steel buttresses are built out at right angles to the plane of the trusses (as shown on the cross-section), thus increasing the width of the superstructure base, and heavy anchors are provided extending down almost to the base of the masonry sub-piers, near their ends. This anchorage is to guard against the effect of winds of extraordinary violence. The stone sub-piers are each 110 ft. by 30 ft. in plan on top, and are 60 ft. above the summer level of the river; they are surmounted by a steel pier 230 ft. high. From the tops of these piers, or towers, the upper chords descend in approximate catenary curves, suggesting the main cables of a suspension bridge, but deviating, for practical reasons, as little as possible from straight lines. The cantilever arms diminish in height to 45 ft. on chord lines at their extremities, whence the mid-span rises in a convex curve to a height of 60 ft. at the center. The web system is a single triangular main system, extending generally over two panels, but over four panels near the towers. The sub-panel length is made uniform throughout and reduced to the moderate length, for such a great bridge, of 25 ft.

The long span and its two flanking spans are divided by the four trusses into three longitudinal ways; the middle one is 26 ft. wide in the clear, and carries the double-track steam railway, while the two side passages, each 21½ ft. wide in the clear, are to be used for the highway, and the street car tracks. The footways, 6 ft. in clear width, are bracketed out from the outer trusses. The grades on the long span are 2 ft. per 100 for the steam railway and 4 ft. per 100 for the highway and electric lines; the latter grade bringing these last-named lines sufficiently low (19 ft.) to permit them to turn under the steam railway near the anchorage piers. The shore spans of the cantilever bridge are 600 ft. long, instead of 500 ft., as called for in the company's plan. But the omission in this design of the rear pair of shore-piers, spaced 110 ft. from the marginal piers, makes the position of the anchor-piers substantially the same. The lower chord of the shore arm is curved downward near the anchorage, with what is believed to be an advantage in appearance and in the economical design of the anchor pier. The roller-beds, allowing expansion or contraction of the shore arms, are placed directly upon the top of the stone substructure of the anchor piers and below the springing of the arched lower chord. Upon these roller-beds rest the steel columns forming the endposts, which posts also support one end of the adjacent viaduct span, the latter is also provided with an arched lower chord. The approach spans have four trusses next to the anchorage and three trusses in all remaining spans; and while these approach spans resemble true arches, they are really designed as arched trusses, and exert no horizontal thrust upon the substructure under vertical loads.

The estimated weight of structural steel in Mr. Shaw's design, exclusive of railways, is 37,000 tons divided as follows: Main cantilever and central span, 19,730 tons; south approach, 13,170 tons; Montreal approach, 4,100 tons. The estimated cost of the superstructure is $3,514,000.

Design by A. L. Bowman.

Fig. 2 represents the design submitted by Mr. A. L. Bowman, of East Hartford, Conn., which took the second prize. In this case the legs of the towers of the main span have a uniform batter of 1 in 10 in both directions, and rest upon four piers spaced 100 ft. apart. The main span is 1,300 ft. long, between centers of river piers, with a mid-span of 300 ft. Mr. Bowman also points out as one of the special features of his design, the curving of the lower chord of the shore-arm of the cantilever at the end nearest the anchorage. The purpose in so doing was to secure a more pleasing outline, giving the general effect of three arches, and to avoid the use of any counterpoise to hold down the end of the shore arms under the worst possible condition of loading.

This structure was designed to be built of steel and with pin-connections throughout. Between the anchor towers the bridge was figured for a live load of 10,000 lbs. per lin. ft., with the approaches of the ordinary pin-connected railway truss bridge type, figured at 10,800 lbs. per lin. ft. With allowances for concentrated loadings in both cases for the floor system. As shown by the cross sections, the highways are removed as far as possible from the steam railways, to avoid danger from hot ashes, grease, noise, etc. The total estimated weight of the steel superstructure in the total length of 5,820 ft., is 85,000,000 lbs., or 42,500 net tons. The weight from out to out of anchor towers, or 2,620 ft., is 55,000,000 lbs., or 27,500 short tons. The estimated cost of the superstructure, including wooden ties, floor and sidewalk plank, is $3,436,500.

Design by Jos. W. Balet.

Fig. 3, the plan sent in by Mr. Joseph W. Balet, of New York, and for which a special prize was given by the bridge company, departs from the conditions of the competition in not being a cantilever bridge. It is a stiffened suspension bridge of 1,400-ft. span from the centers of the main towers, or 1,270 ft. from the centers of the river posts of the towers, and 2,130 ft. from anchorage to anchorage. It should be remarked, however, that the design here given has since been altered in details to facilitate the required equipment with railway tracks and highways. So far as proportions were concerned, this bridge was designed for two steam railway tracks, with a live load of 3,000 lbs. per lin. ft. for each track; two electric railway tracks, with a live load of 680 lbs. per lin. ft. of track; two wagon roadways with a live load of 700 lbs. per lin. ft. or road, and two footways with a live load of 420 lbs. per lin. ft. of way. The clear height of the bridge above high water is 154 ft. and the height of the towers is 366 ft. above the water-level. The width of the bridge from out to out is 102 ft. The estimated weights for the steel superstructure are as follows:

Two land spans, etc.	4,282 tons.
Two towers, anchorage, etc.	4,800 "
One stiffening truss.	4,560 "
Total structural steel.	13,642 tons.
Wire, etc., in cables.	2,340 "
Total masonry	14,050 cu. yds.

The total estimated cost of the bridge, including $140,000 for the masonry, is $1,730,000 for the structure complete in all details. This estimate, however, seems to cover only the bridge between the anchorages, or 2,130 ft. Including the approaches and the Montreal terminal station he puts the total cost at $6,000,000. Mr. Balet claims for his design the strength of the cantilever bridge, both for live load and wind pressure, with a more pleasing form, and a much decreased cost. At Fig. 3a is shown a special floor-beam devised by Mr. Balet. This beam is hung up in two places to the floor truss, shown in heavy lines in Fig. 3b, and forms a continuation of the lateral braces. These trusses and braces are designed to transmit wind pressure from the top to the bottom chord and under the floor system are the wind braces. This floor-truss and lateral bracing extend through the whole length of the bridge, at every panel point, and in the center of each panel; and they also mark the points where the suspenders connect the stiffening truss and the cables. By this arrangement Mr. Balet proposes to transmit the dead load of the top-chord and web-members immediately to the suspenders and to the cables.

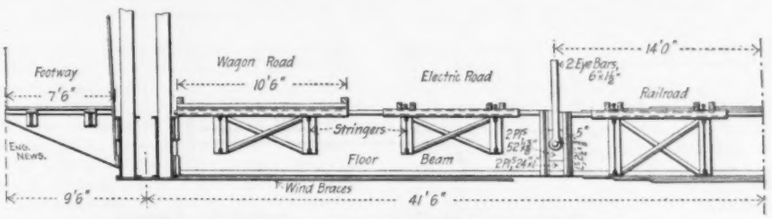


FIG. 3a.—SPECIAL FLOOR BEAM, DESIGN OF MR. J. W. BALET.

Design by Henry Szlapka.

Fig. 4 represents the plan of Mr. Henry Szlapka, of Trenton, N. J. The principal features of this design may be noted as follows: The length of the main span is made 1,200 ft., instead of 1,250 ft., because Mr. Szlapka believes that the Montreal quay can be widened 50 ft., allowing the span to be reduced that much. As the foundation con-

ditions are good, he reduces the longitudinal width of the towers from 110 ft. to 14 ft., thus decreasing cost of extra foundations and considerably reducing the weight of the bridge, "without sacrificing strength or rigidity." The two trusses are spaced 44 ft., center to center, giving a ratio of 27 of width to length, "enough for lateral stability, according to the best modern practice, while keeping the weight of the floor-system within reasonable limits." The trusses are placed in vertical planes, and the lateral and sway-systems are

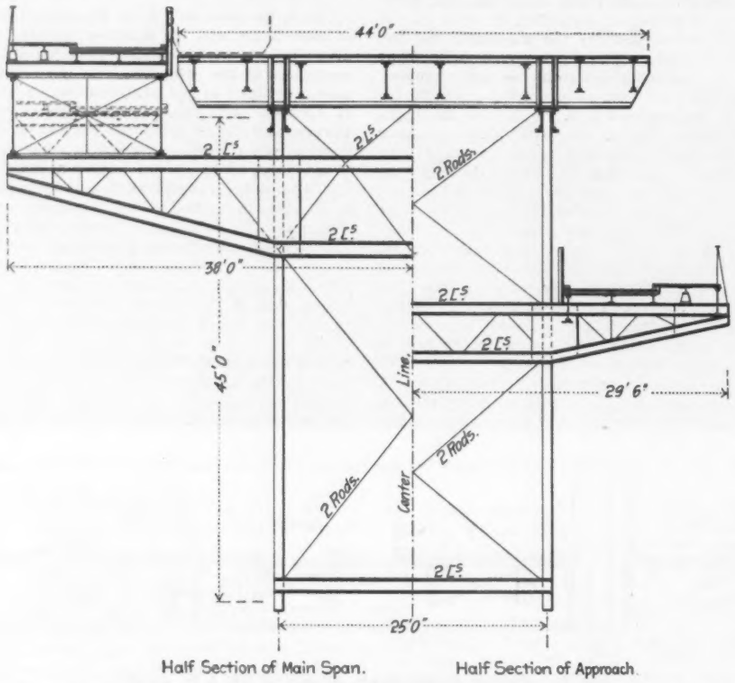


FIG. 4a.—MAIN SPAN AND APPROACH SECTIONS, SHOWING RELATIVE POSITION OF RAILWAY AND ROADWAY LEVELS. DESIGN OF MR. HENRY SZLAPKA.

double intersection trusses built with stiff members throughout, with sufficient strength to hold the structure rigid against vibrations from live load and against a wind blowing with a velocity of 100 miles per hour, corresponding to a pressure of 50 lbs. per sq. ft. on the exposed surface of the whole bridge. In making the objection that the center tower is too high for the width, the designer says that "the dead load of the structure is in excess of that required to make the structure safe against the overturning tendency of the highest wind by a factor of safety of about two." The railway tracks are placed in the center of the bridge, and spaced 13 ft. apart, so that the loading of one track only will produce no appreciable twist on the cross section of the bridge; the electric car tracks are arranged outside the trusses, one on each side. In the portions of the bridge where, on account of the curvature of the bottom chord, the wind produces a heavy torsion in the cross-section; this tendency is resisted by extra curved brackets, which together with the floor beams, make a solid cross bracing.

In the approach spans bending strains on the posts and interference with the trusses at any place have been avoided by the arrangement shown in Fig. 4a; the trusses being placed 25 ft. apart, c. to c., carrying the two railway tracks directly on the floor system, while the rest is carried on brackets. Expansion and contraction is provided for by placing the trusses on rocker-bents. Three braced towers have been arranged by making the bottom chord stiff throughout, and running knee braces from this chord to the foot of the bents.

The estimated weights and cost for the whole structure are not given in such form that they can be safely stated here without further data, but the estimated weight of the main span of 2,080 ft., end to end, is set down at 30,000,000 lbs., or 15,000 net tons, and the cost, if made in the United States, at $1,479,000, including anchorage and pedestals, and customs duty at 1 ct. per lb. The weight of an average 250-ft. approach span is not to exceed 1,000,000 lbs. and the cost, on above conditions, $39,500. The 240-ft. spans on the Montreal approach are figured at 92% of these latter amounts, and the 180-ft. span at 60%.

Design by C. C. Wentworth.

Fig. 5, the design submitted by Mr. Charles C. Wentworth, M. Am. Soc. C. E., of Roanoke, Va., is for a stiffened suspension bridge of 1,300 ft. span, with a cable deflection of one-seventh of this span; the side spans are 500 ft. each, with the aggregate length of 2,300 ft., divided into panels of 25 ft. each. The cables over the side spans are intended to be segments of a parabola, which, if produced, would be double the span and deflection of those of the central span; and these cables will be attached by suspenders to each panel point in the side trusses. This proportion is adopted to reduce the vertical force at each suspender to one-half of what it is in the main span; or 56,250 lbs. on each suspender, as compared with 131,250 lbs. on each central suspender, with the weight of the cable considered. There would be four cables, each built up of 3,800 No. 3 steel wires, with a finished diameter for the cable of 17½ ins. To insure durability it is proposed to cover each cable, after wrapping and painting, with a cylindrical cover of sheet copper, or possibly aluminum, with the saddles to be covered by a copper hood. To prevent possible slipping of the suspender clamps on the cables it is proposed to connect the pins in these clamps by lines of eye-bars under the cables.

The steam railway tracks are located in the center of the bridge, and the electric lines outside of them, with the highways and footways on brackets, as shown in the cross-section. The stiffening trusses of the central span are hinged in the middle of the span and proportioned to prevent undue distortion of the roadway under partial loads; it is not proposed to make use of diagonal stays. The depth of this stiffening truss is 50 ft. c. to c. of chords, and both ends are free to move longitudinally under changes of temperature. The weight carried by the towers at the top is, for all cables combined, 30,600,000 lbs., while they also carry, lower down, the ends of the side spans. The approach spans are of the ordinary pin-connected type.

The aggregate estimated weights and cost are given as follows:

11,000,000 lbs. riveted steel center span	$467,500
20,000,000 " steel in towers, side spans and anchorages	700,000
30,000,000 lbs. steel in approach spans and piers	900,000
8,000,000 " steel wire in cables	480,000
Copper covering on cables	20,000
Timber floors and ties	81,000
600 tons steel rails	18,000
60,000 cu. yds. anchorage masonry	360,000
Hand railing, etc.	25,000
Total cost	$3,051,500

Design by Jas. Ritchie.

Fig. 6 represents the design of Mr. James Ritchie, M. Am. Soc. C. E., of Cleveland, Ohio. The channel span and anchorages have a total length of 2,470 ft., divided as follows: Two anchorage arms of 500 ft. each, two central panels of 110 ft. each, two cantilever arms of 450 ft. each, and one central suspender span of 350 ft. On this span the cantilever trusses are 100 ft. apart c. to c., at the floor level, and have a batter of 1 in. per ft. The depth of the central panel is 250 ft., and at the anchorages and at the middle of the suspended span the depth is 80 ft. All roadways are on a level, with the four railway tracks located 13 ft. c. to c., leaving two carriage ways, 20 ft. wide in the clear, and two footways of 8 ft. clear width.

The main panels in the cantilever are 100 ft. long each, subdivided into half-panels of 50 ft. each, and the panels in the suspended span are 50 ft. each. At each panel and half-panel point is placed a transverse truss 20 ft. deep, with the bottom chord 25 ft. above the floor line. This transverse truss supports three intermediate lattice trusses, 50 ft. span, and 27 ft. deep; and there are two other lattice trusses extending from post to post in the line of each main truss, serving the double purpose of supporting the floor and adding longitudinal stiffeners to the structure. The floor beams rest directly upon the bottom flanges of these lattice trusses, and are riveted to them. The approach trusses are spaced 25 ft. apart. The estimated weight of the entire structure is given as follows:

	Tons.
Approach spans and towers	38,000
Main span and anchorages	26,000
Total weight	64,000

The estimated cost, including all floors, steel rails, erection of steel work, painting, all erecting plant and the removing of the last, is $6,250,000. This cost is equivalent to $590.00 per lin. ft. for the approach spans, and $1,160 per lin. ft. for the cantilever spans.

Design by Chas. H. Wright.

Fig. 7 is a plan submitted by Mr. Charles H. Wright, M. Am. Soc. C. E., of Wilmington, Del. Mr. Wright specifies the peculiar arrangement of the top-chords of the cantilever span as being, in his judgment, an excellent feature of his design. By the arrangement proposed he avoids "the use of excessively long pins, and at the same time insures an equal distribution of strains." His chief idea has been to use throughout such sections and sizes as any of the larger bridge companies can readily manufacture. On the approaches he proposes towers, 25 and 30 ft. in longitudinal length, between the spans, one end of each span being fixed to the tower and the other end moving on a rocker connection to allow for expansion. The quantities as well as general dimensions are given as follows:

	Weight—lbs.
2 cantilever spans of 1,110 ft. each	36,570,000
1 250-ft. suspended span	1,220,000
17 250-ft. approach spans	20,594,921
9 120-ft. " "	3,018,078
2 cantilever towers	750,000
9 towers under 120-ft. spans	975,000
15 towers under 250-ft. spans	3,684,765
Total weight	66,813,364

The total estimated cost of the above metal work erected at 2 7-10 cts. per lb., would be $1,803,960. To this Mr. Wright adds $33,560 for fencing and $75,000 for lumber, at $22 per thousand, B. M., making the total estimated cost $1,911,520.

Design by C. R. Grimm.

Fig. 8 illustrates a non-competitive design for the Montreal bridge submitted by Mr. C. R. Grimm, M. Am. Soc. C. E., of Trenton, N. J. It is

a sickle-shaped truss, hinged at the supports and continuous throughout, with parabolic top and bottom chords and a single system of web-members. The length of span is 1,200 ft. c. to c.; at the middle of the span the top chords are 30 ft. apart and the bottom chords 39.4 ft. apart; at the supports the trusses are 80 ft. apart c. to c. The rise of the bottom chord is 200 ft., and the height of the arch at the crown is 60 ft., with a clear headway of 150 ft. The main trusses are provided with a complete system of windbracings and carry the deep and heavy floor of 40-ft. panels by means of either cable suspenders or stiff members. In this connection the designer points out the fact that, as compared with suspension bridges, the place of the main cables is taken by a steel arch of great rigidity, and a stiffer structure can be designed than for a railway suspension bridge. The floor would be a horizontal truss completely braced; and to further protect this floor against wind action, two cables, in horizontal planes, are inserted and fastened to every floor beam. The ends of the suspended floor are attached to massive cross-girders placed between the main truss, and on these same girders rest the two adjacent independent spans of 100 ft. each. Pins are proposed for suspending the floors, to facilitate erection and to minimize the secondary stresses.

In thus proposing for the first time for a railway bridge a sickle-shaped truss of 1,200-ft. span, Mr. Grimm says he has adopted in his calculations the most modern analysis, based upon the principles of least work and virtual velocities. Three different conditions of loading have been assumed; the entire span loaded, one-half loaded, and a load covering 540 ft. symmetrically grouped about the crown. The vertical deflections for the above assumptions are, at the crown, 14, 16 and 10 ins. In a truss of this form the temperature stresses are very moderate, as compared with primary stresses, and the designer says that a variation in the temperature of 75° F. resulted in a horizontal reaction of only 57 tons, and in a vertical crown deflection of 5.4 ins. Mr. Grimm figures that four different sections in the top chord and a uniform section throughout the bottom chord would meet all requirements. These chords could be built of plates and angles with a depth of about 4 ft.

The sickle-form of braced arch is selected, as being the most economical in point of weight of any braced arch, and consequently very much lighter than any truss bridge. The estimated weight of this arch proper, including the anchorages, is 6,500 tons; the weight of the six independent spans and towers is 2,500 tons; making a total of 9,000 tons for a length of 2,080 ft. Mr. Grimm concludes that as compared with a cantilever bridge of similar span, the saving would represent 5,000 to 6,000 tons of steel.

In connection with the important point of erection, Mr. Grimm consulted a firm of international reputation, the "Gutehoffnungshuette," of Germany. This firm advised erection as a cantilever; the end panels of the arch, for 240 ft. beyond the supports, and the single spans could be erected on falseworks. The remainder of the arch proper could then be built up cantilever-fashion at an estimated cost of $16 per ton for the erection of about 4,000 tons of metal; the work on falseworks would cost about $8 per ton, according to this firm.

Mr. Grimm summarizes the claims for a sickle, as compared with a cantilever bridge, as follows: It can be built as rigid and stable as first class practice and experience require; the average saving in dead weight is 33%; it can be erected with the same advantages as the cantilever bridge; it is superior in appearance and costs less money.

Design by Francois Bicheroux.

Fig. 9 represents a design submitted by M. Francois Bicheroux, of Belgium. This is a double sickle-shaped truss, hinged at the crown, as well as at the supports. The main span is 400 m., or 1,312 ft. between centers of supports. At each shore end the designer proposes to erect two steel towers, each 328 ft. high, which would be guyed back to anchorages, and serve as points of attachment for cables to be used in the erection of the truss members after the manner of erecting a cantilever bridge. He says that these towers could be removed after the completion of the bridge; but he thinks they would be useful as lighthouses for the port of Montreal, and would be "certainly decorative." The top and bottom chords of the main arch would be double tubes; an outer tube 2 m., or 6.56 ft. in diameter, with an inner tube of 1 m., or 3.28 ft. diameter, connecting with the other one by 6 radial plates, with angles and cover pieces. The proposed connection of the web-system with these tubes is shown in Fig. 9a. The massive castings forming the hinge connection with the tubes is shown in Fig. 9b.

The estimated weight of the 400 m. span is 9,016 metric tons, or 8,836 long tons. The weight of metal in the whole structure, including the two towers is 28,977 metric tons, or 28,297 long tons, and the estimated cost is 17,300,000 francs, or $3,460,000.

Design by C. J. Welch.

Fig. 10 is the plan of Mr. C. J. Welch, of Youngstown, Ohio. It is of the cantilever type, with a total length of 2,470 ft. between anchorages, divided as follows: Two shore arms of 500 ft. each; two pier panels of 110 ft. each; two river arms of 450 ft. each, and one central span of 350 ft. The approach spans are of the usual type and in spans of 250 and 240 ft. Mr. Welch proposes to adopt the "Baltimore" truss panel to the cantilever bridge, with the panels increasing in length as they approach the pier. The estimated weight of the cantilever and center spans and the anchorage towers is 52,035,920 lbs., the towers figuring at 2,462,200 lbs. The total weight of the whole superstructure, including 260,000 lbs. of railing is 88,573,160 lbs., and the estimated total cost is $5,632,125.

Design by Henry E. Mertens.

In Fig. 11 Mr. Henry E. Mertens, of Chicago, Ill., submits a design for a cantilever bridge of 1,250 ft. span. But his plan varies from any of the preceding cantilever designs in reducing the shore-arm of the cantilever to 250 ft., with a span of the same length connecting the main bridge with the approaches. The two cantilever trusses are placed 62½ ft. apart, c. to c., leaving 50½ ft. of clear space between them. He places the railway tracks on brackets outside the trusses. In reducing the length of the shore arms of the cantilevers, Mr. Mertens says he was influenced by the advisability of using masonry at $4.00 per ton as a counterpoise to the main span, rather than structural steel at $75 per ton.

The estimated weight of the cantilever span of 1,750 ft. is 38,878,000 lbs., and the estimated total weight of metal in the whole bridge is 84,449,000 lbs. The estimated total cost, including roadways, rails and engineering, is $3,200,000.

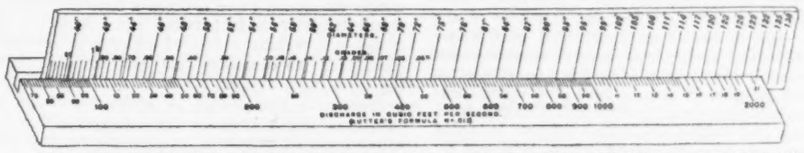
Design by T. Kennard Thomson.

Fig. 12 shows one of several designs submitted by Mr. T. Kennard Thomson, M. Am. Soc. C. E., of East Stamford, Conn. As no written description accompanied the plans, no details can be given other than are indicated on the plans. He estimates the cost of the channel span of 1,780 ft. at $1,450,000, and the total cost of the entire structure is $3,140,000.

Design by Charles Steiner.

Fig. 13 represents the plan submitted by Mr. Charles Steiner, of Pittsburg, Pa. The channel span of 1,250 ft. is a "trussed arch," with the crown 400 ft. above the river surface, and the foot of the truss 200 ft. wide at the abutting points. The roadway is to be suspended, and the approach spans are of exceedingly peculiar design. Mr. Steiner proposes to erect the main trusses by making use of bracket-trusses, 200 ft. long, at each end, and by erecting a central temporary tower in the river, which is to support temporary trusses extending to the brackets upon which the main trusses would be built.

The estimated weight of the main span is 15,621,000 lbs.; and for the whole structure, 61,057,000 lbs., including 1,152,000 lbs. of cast iron. The total estimated cost is $2,337,863; but no mention is made of the specific cost of erection.



COMPUTER FOR CALCULATING DIAMETER, GRADE AND DISCHARGE OF CIRCULAR AND EGG-SHAPED SEWERS BY KUTTER'S FORMULA. B. H. Colby, M. Am. Soc. C. E., St. Louis, Mo., Designer.

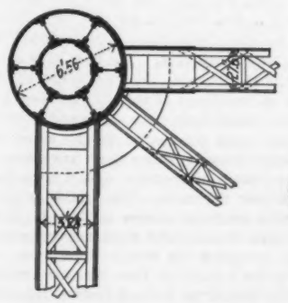


Fig. 9a.—Detail of Connection between Web System and Tubular Chords. Design of Francois Bicheroux.

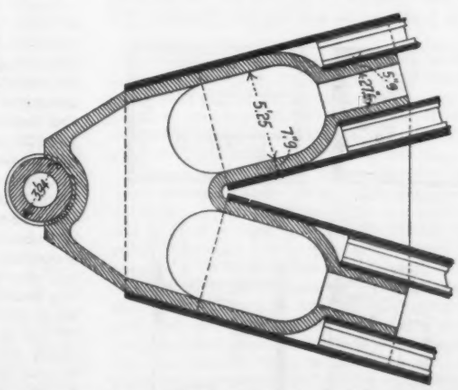


Fig. 9b.—Hinge Connection of Tubular Chords. Design of Francois Bicheroux.

THE COLBY SEWER COMPUTER.

We illustrate herewith a slide rule designed to take the place of the diagrams and tables heretofore generally used in computing the discharge, diameter and grade of circular and egg-shaped sewers. This instrument was designed by Mr. B. H. Colby, M. Am. Soc. C. E., Sewer Commissioner, St. Louis, Mo., and has been used in designing all the sewers constructed in that city during the past year, and found to be thoroughly practical. Briefly described, this computer is Kutter's formula in the form of a slide rule. The values obtained are the same as given by Kutter's formula; the value of the coefficient n being taken at .013. The cut shows only a portion of the entire computer. The divisions on the limb represent discharge in cubic feet per second, while on the slide are two scales, the divisions of one indicating different diameters of sewers in inches; the divisions of the other representing the per cent. of grade. The following three examples illustrate the use of the computer:

(1) Required: The discharge of an 81-in. sewer,

having a grade of 1%. Set 1% division on slide opposite 100 mark on limb, then opposite 81-in. division on slide read on limb 590 cu. ft. (2) Required: The diameter of a sewer that will discharge 590 cu. ft. on a 1% grade. Set 1% division on slide opposite 100 mark on limb, then opposite 590 mark on limb read 81 ins. on slide. (3) Required: The grade of a sewer 81 ins. in diameter to discharge 590 cu. ft. per second. Set 81 ins. on slide opposite 590 mark on limb, then opposite 100 mark on limb read 1% on slide. All problems, for all other grades, diameters and discharges, are solved in a similar manner.

Upon the opposite side of the slide are scales of diameters and grades for egg-shaped sewers. All problems relating to egg-shaped sewers are solved in the same way as those for circular sewers given above, the sides of the slides being reversed. The limits of the computer are as follows: For circular sewers, 6 ins. to 20 ft. in diameter; egg-shaped sewers, 12 ins. x 18 ins., to 12 ft. x 18 ft.; grades for both circular and egg-shaped sewers from 0.05% to 20%.

In calculating the values of c. in Kutter's formula for use in designing the rule, all values were carried out to four decimal places, and every result was carefully checked. The end aimed at in the design was to secure an instrument that would give absolutely accurate results; as accurate as if the formula was used in each case. So successful was the designer in this respect that every computer is guaranteed to be accurate. The rule is 21 ins. long, and weighs only a few ounces. It is sold by the A. S. Aloe Co., of St. Louis, Mo., and by the various houses of Keuffel & Esser.

NEW METHOD OF UNDERPINNING HEAVY BUILDINGS.

The recent rapid increase in the number of high office buildings in our larger cities and the difficulties arising from the necessity for digging deep

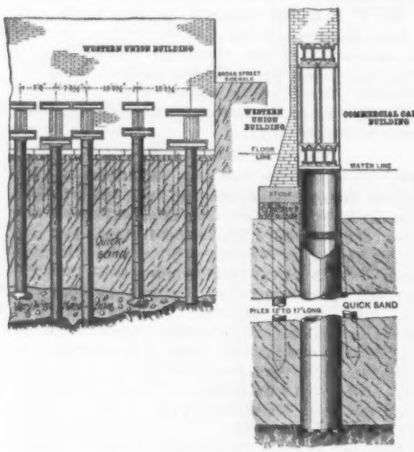


Fig. 1.—Sections Showing Method of Underpinning Western Union Building while Constructing Commercial Cable Building on Adjoining Lot.

foundations adjacent to the comparatively shallow foundations of older and lighter structures have developed many new and interesting engineering problems. One of these problems, and one of the most difficult of common occurrence, is the support of the wall of an old building while digging deep into the adjacent soil and below its base.

An ingenious solution of this problem has been devised and patented by Mr. Jules Breuchaud, Assoc. Am. Soc. C. E., of the contracting firm of Arthur McMullen & Co., of New York city. His method may be briefly described as follows: As soon as the excavation for the new foundation has reached the bottom of the old foundation a number of horizontal recesses are cut in the latter, as shown in the illustration, and in these recesses are placed a series of horizontal beams. The next operation is to cut out the masonry just below these beams, leaving enough to afford an abutment for the ends of the beams, and to set up in this vertical recess a hydraulic jack with a section of an iron column, or pipe, beneath it. This section is forced down by the hydraulic jack and other sections are successively added until rock or other firm material is reached. When this is accomplished the jack is removed, another series of beams is put in place at the base of the old foundation and the vertical recess between the two sets of beams is filled in with masonry or with steel posts tightly wedged between the two sets of horizontal beams, and these enclosed in masonry. After that the excavation of the new foundation is proceeded with in the ordinary manner. In practice this method has so far worked economically and securely, without materially interfering with the general run of the work.

As these supporting columns are more or less widely separated there is often a caving tendency in the bank of earth between the columns, even though the weight of the old building is perfectly sustained. To overcome this tendency and avoid the consequent danger, Mr. R. S. Gillespie has improved upon this device by sinking sections of sheathing plank between the columns either by water-jet or by pressure. In this case the columns have cast upon them vertical flanges serving as guides to the sheathing. This sheathing is sunk in sections made up of planks laid horizontally and tied together by pairs of iron rods at each end of the section. A tube at each end is so arranged as to conduct water to the hollow perforated shoe of the bottom section.

Since the above was written Mr. Breuchaud has submitted a paper upon this subject to the American Society of Civil Engineers, and from this paper some further details are taken. The first trial of this process was in connection with the foundation work of the Commercial Cable Building, at Broad and New Sts., New York, in supporting an adjoining four-story building. The bottom of the foundation wall of this building was 33 ft. above the hardpan to which the pipes were carried, and 23 ft. above the bottom of the cellar of the proposed building. The pipes used here, 9 in a space of 57 ft., were heavy steam pipes, 10 ins. in diameter, ⅜-in. thick and having a cross-section of 12 sq. ins., with a weight of 40 lbs. per lin. ft. They were sunk in lengths of 5 ft. and connected with outside couplings and butt-joints. Every alternate pipe contained a smaller interior pipe, arranged to break joints, and the annular space was

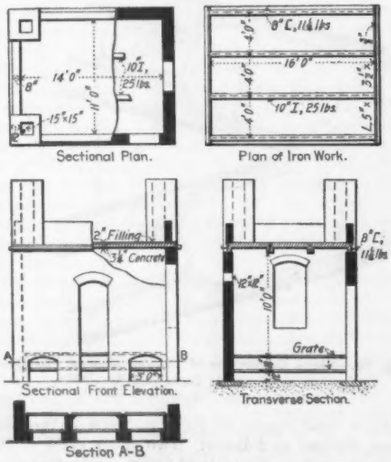


Fig. 1.—Building Used in Test of the Columbian Fireproof Flooring.

filled with Portland cement grout; while the whole pipe was later filled with Portland cement concrete. A 60-ton jack was used, and operated to its full capacity, and it thus imposed a load upon each pipe greater than it had to bear ultimately.

Under the adjoining Western Union Building heavier pipes were employed and these were sunk through the hardpan and boulders to rock. To permit this the pipes were 28 ins. in interior diameter and were made of cast-iron; and while most of the excavation was done by hand, the presence

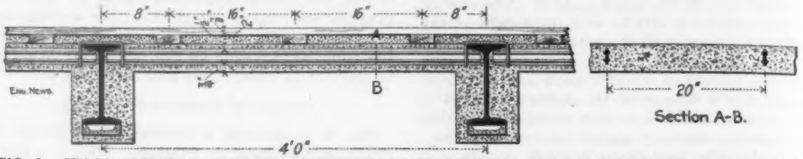


FIG. 2.—CROSS-SECTIONS OF CONCRETE FIREPROOF FLOORING OF THE COLUMBIAN FIREPROOFING CO.

of water in the ground finally made it necessary to add a portable air-lock and to carry on the work in compressed air. Nine pipes were used in a length of about 88 ft. and no movement of any kind occurred. The adjoining Stock Exchange foundation was treated in a similar manner with 6 30-in. pipes in a length of 68 ft.

In the next application of the process, at the 11-story Stokes Building, the foundation to be treated was spread over a sand surface without

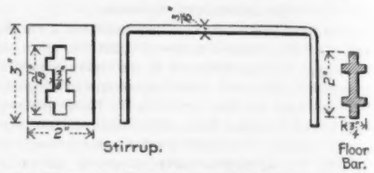


Fig. 3.—Stirrup and Floor Bar—Used in the Columbian Fireproof Flooring.

supporting piles, and it was estimated as carrying a load of 45 tons to the square foot. The new structure (the Queen's Insurance Building), was to be founded upon piles, and it was feared that the driving of these piles would cause a flow of quicksand from underneath the Stokes Building. The seven columns here used were made of cast-iron and were 33 ins. interior diameter and 1½ ins. thick. These columns were driven into hardpan and enlarged at the base and filled with concrete, and the pile-driving work was carried on without damage to the adjoining foundation. Another foundation, at Wall and Nassau Sts., was supported in a similar manner by 16-in. lap-welded steel pipes ⅜-in. thick.

TEST OF THE COLUMBIAN SYSTEM OF FIREPROOF FLOORING.

In our news columns last week we gave a brief account of a fire and water test of a floor constructed by the Columbian Fireproofing Co., 156 5th Ave., New York city. We now give some further details of the test. It was made by the Department of Buildings of the City of New York, at the testing ground at 68th St. and Avenue A on Dec. 23, and was conducted in the same manner as the tests of other floors that have been made during the past four months, which have been described in our columns. The building in which the test was made is shown in Fig. 1. Two sets of grate bars were placed near the bottom of the structure, covering its whole floor area, one 18 ins. above the other, so that the air entering at the bottom would be heated before reaching the main fuel bed, which was of cordwood. Chimneys 15 ins. square and 6 ft. high above the roof provided the draft. The floor construction, which formed the roof of the structure is shown in Fig. 2. The floor is constructed in three panels, resting on 10-in. I-beams placed 4 ft. apart between centers. Ribbed steel bars 2 ins. deep, placed 20 ins. c. to c., are suspended from the upper flanges of the beams by stirrups, which hold the bars in place. A bed of concrete 3¼ ins. thick is then laid so as to enclose the steel bars, and flush with the top of the upper flange of the beams. The strength of the floor betwen the I-beams is thus due to a combination of the concrete and the steel bars.

The concrete is made of 1 part Portland cement, 2 parts sand and 5 parts broken stone. The lower portion of the I-beams is protected by a mass of

concrete, with an air space under the bottom flange, as shown in Fig. 2. This forms what is known as a panel ceiling. Above the 3¼-in. bed of concrete are placed 2 × 3-in. flooring strips 16 ins. c. to c., with the spaces between them filled with a weak concrete of 1 part cement, 5 sand and 10 stone screenings; and on top of the strips is nailed a ⅞-in. flooring. The age of the floor was 30 days at the time of the test.

On Dec. 22 the central span of the floor was loaded with 150 lbs. per sq. ft. of pig iron equally distributed. The test was begun the next day by lighting the fire at 10:30 a. m. Within 30 minutes a temperature of 1,800° was attained, and 2,000° was reached a few minutes later. A temperature of from 2,000° to 2,200° was then steadily maintained until 3:30 p. m. The temperatures were measured with a Uehling & Steinhart registering pyrometer. At 3:30 p. m., or 5 hours from starting, water was applied from an engine furnished by the Fire Department, at a pressure at the engine of 60 lbs. The stream was played on the under side of the floor for 15 minutes, and then the upper side was flooded with water for five minutes. The force of the stream was such as to disintegrate the surface of the side wall of the building in several places. An examination of the floor after the test was concluded showed that some of the slab casing on the flange of the beam and a portion of the concrete underneath the bars in the central span had been washed off by the force of the water. The floor itself, however, was intact, and there were no holes or openings in it. The maximum deflection of the floor measured before applying the water was about 3½ ins. After cooling with water this decreased to about 3 ins., the 10-in. I-beams themselves having sustained a permanent deflection in the center of this amount.

The results of this test are considered highly satisfactory, especially when it is considered that the paneled system of flooring is a more exposed form of construction than a flat ceiling system would be. The floor was not protected by a ceiling of any kind. The test also gives additional evidence of the great resistance of concrete to long continued fire.

A subsequent weight test of the floor was made on Dec. 29 by loading the central span with a uniformly distributed load of 600 lbs. per sq. ft., or four times that carried during the fire test. The beam deflected ½ in. at the center under this load, but the floor itself was entirely uninjured.

THE HISTORY OF THE MONONGAHELA NAVIGATION CO.

The history of the attempt to secure the aid of the federal government in providing slack-water navigation on the Monongahela River, says the Pittsburg "Times," of Nov. 28, dates back to 1832. As early as 1828, Mr. Edward F. Gay, C. E., then State Engineer of Pennsylvania, attempted to induce the State to develop the commerce of that river by constructing a series of locks and dams, but the Pennsylvania Canal was then nearly completed, at a cost of about $40,000,000, and this outlay, imposing an enormous burden of debt upon the State, made the legislators wary of incurring the added expense of improving the Monongahela. The State Canal was finally sold to the Pennsylvania R. R. Co. at less than one-sixth of its cost.

Under these conditions, Andrew Stewart, of Fayette County, commenced to seek national aid for the enterprise, in 1832, and Congress went so far as to order a survey, and a plan was submitted calling for eight dams, 4½ ft. high each, which were to serve navigation purposes during low water. But when the time came for appropriations to put this plan into execution the money was not forthcoming.

Meanwhile, traffic upon the river grew, for in 1825 the first steamboat was placed upon the river, and ran between Pittsburg and Brownsville, when the stage of water permitted. In 1836 a private corporation was formed to build the necessary locks and dams to the Virginia line, and as much further as the State of Virginia would permit. The capital was $300,000, and the United States Bank, of Pennsylvania, was required by its charter to take $50,000 of such public improvement stock whenever $100,000 was taken up by others. This bank broke when but half its subscription of $125,000 was paid, the State bonds issued for this canal were sold at a loss, and the financial panic of 1837 added to the difficulties of the company. In 1838 the late Milnor Roberts, later President of the American Society of Civil Engineers, was made the engineer of the work. He found that in the 34 miles between Pittsburg and Brownsville the river fell only 34 ft., and in the 35 miles between Brownsville and the Virginia line it fell 41 ft., or a total fall of 75 ft. in 69 miles. Mr. Roberts decided to use higher dams than 4½ ft., and after considerable absurd difficulties in inducing the legislators to amend the charter to this effect, he laid out five dams, in place of the eight first proposed. The estimated cost of these dams was $335,616, and the contract for the two nearest Pittsburg were let to B. & G. K. Moorhead, and to Philips, Duncan & Duncan, the latter contract being later given to Corey & Adams.

Work was commenced in 1840, and in 1841 these two dams were finished, and dams 3 and 4 were turned over to the company in 1844. But financial troubles thickened, and in 1843 dam No. 1 was partially washed away, and the credit of the company was exhausted. In this emergency J. K. Moorhead and other business men of Pittsburg bought from the State, at $3 per share, such Navigation stock as it held, and by adding more money infused new life into the enterprise, and speedily finished the work to Brownsville. The Baltimore & Ohio R. R. was then open to Cumberland, and a stage route was made over the 73 miles, between that point and Brownsville. The trip to Baltimore was thus made in the "remarkably short time of 30 hours," by using the river, the stage and the new railway. In 1844, the Pittsburg & Brownsville Packet Co. had been organized, and a new passenger route to the East was instituted, and proved so popular that in 1847 the through passengers numbered 45,825, and the way passengers 39,777. These figures increased in 1848, but the Pennsylvania R. R. had been gradually pushing over the Allegheny Mountains, and in 1852 the packet's through passenger list had fallen off to 25,613; but the way passengers in this year numbered 88,233, and the company was prosperous until the further extension of railways killed this class of business.

But the development of the coal trade opened up an era of prosperity not foreseen by the original projectors of the improvement of this river. This trade practically began in 1845, with the shipment of 4,605,185 bushels of coal, paying $5,283 in tolls. In 1890 the shipment of coal by this route amounted to 116,902,600 bushels, and the revenue from tolls was $204,233; and it is estimated that in all about 3,000 millions of bushels have been sent through these locks, and that $5,000,000 has been collected in tolls. The annual report of the company for 1895 charges up to the construction account $1,933,207, and values real estate at $100,000, and against this stands stock, bonds and script to the amount of $1,946,000. Including its franchise, the company now values its property at about $3,000,000, as the 1895 report shows an income of $296,523, with $103,242 expended in operation, repairs and taxes.

Those now interested in the further improvement of this river by the government, believe that $3,500,000, or less, will buy the company's rights and properties, and that for $3,000,000 more the government can put in new and larger locks and develop a commerce that would surely follow the conversion of the river into a free navigable channel. Viewers are now at work inspecting the system, and attempting to fix its earning power and general value, under the Act of Congress directing the Secretary of War to institute and carry to completion proceedings for the condemnation of the Monongahela Navigation Co., under the general railway law of Pennsylvania, of 1849. Upon final judgment, the Secretary is empowered to draw his warrant for the sum awarded. A previous attempt of Congress to buy dams 6 and 7 had failed, owing to the small price offered, and the decision of the Supreme Court that compensation for the franchise must also be considered.

Since writing the above the viewers, appointed by the government to ascertain the present value of the property, have completed their investigation and Jan. 19, 1897, has been fixed upon as the date of the public hearing. The canal owners still value the 33,000 shares of stock at $100 each, as they say that each share has earned $6 annually for some years past. With some other property added, the latest valuation by the canal owners is about $3,800,000.

ANOTHER DECISION REGARDING THE USE OF COAGULANTS IN MECHANICAL WATER FILTERS

The use of a coagulant in mechanical filters has again been pronounced as an infringement on the patent No. 293,740, granted to Isaiah Hyatt, Feb. 19, 1884, and owned by the New York Filter Manufacturing Co. The former decision to this effect was noted in our issue of June 28, 1894. In that decision the judge distinguished between the use of alum, where settling tanks intervene between the admission of the alum to the water and the passage of the water to the filters and its use where tanks are not employed, limiting the injunction to plants without such tanks. Both suits were brought against users of the Jewell filter, the first suit being brought by the New York Filter Co., and the second by its successor, the New York Filter Manufacturing Co. The outcome of the last suit was the granting of a preliminary injunction against the use of Jewell filters by the Niagara Falls Water-Works Co., the suit being in the U. S. Circuit Court for the Northern District of New York, and the opinion being by Judge Coxe.

Since the decision of 1894, some, if not all, competitors of the New York Filter Manufacturing Co. have been relying upon the use of settling tanks to avoid infringement of this Hyatt patent, relying largely on the following sentences in the decision of the U. S. Circuit Court of Appeals:

> In some of the plants of the corporation defendant settling tanks are used between the introduction of the coagulant and the filter-bed. In these plants the method of the patent is not appropriated and there is no infringement.

The defendants in the case just decided claimed that they had settling tanks that would exempt them from infringement, in view of the above statement. The tanks in question have a capacity (Eng. News, May 28, 1896) of 38,000 gallons and the filters a daily capacity of 4,500,000 gallons. The court held that the passage of the water through the tanks at so great a rate as would be necessary with the present output of 3,500,000 gallons per day affords no time for sedimentation, as practiced when the patent was granted, the inventor stating in his description that "settling basins or reservoirs as now commonly employed" are unnecessary in his process. Aside from this prima facie evidence the judge cites testimony submitted by the complainants which he considered as establishing beyond a doubt that practically no sedimentation occurs in the Niagara Falls plant, the whole work being done by the bed. Evidence to the contrary, submitted by the defendant, he dismissed as inconsequential.

We are informed that the Niagara Falls Water-Works Co. has taken the case to the U. S. Circuit Court of Appeals; also that a hearing on a stay of the injunction will be heard on Jan. 12 and that possibly the injunction may not be formally served until after the hearing on appeal.

PYROCOLLODION is a new explosive invented by Prof. Mendeleff, of Russia, and described in the Russian "Naval Magazine." It is claimed to be a new form of smokeless powder, first made in 1892. It is a form of nitro-cellulose, midway between ordinary gun cotton, containing 13% of nitrogen, and collodion, containing about 11½%. The inventor claims for it—homogeneity of substance, and regularity and completeness of combustion.

ASPHALT, or mineral tar, as the analysis terms it, has been found in the District of Sota de la Marina, Mexico, says U. S. Vice Consul J. Bielenborg, of Matamoros. The asphalt deposits cover 20 sq. miles, and an analysis by the State University of Texas pronounces the samples as very rich in a natural mineral tar. A lease of the lands for 50 years has been secured and a company is being organized in the United States to work the deposits, to put in machinery and to drill for oil.

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AND
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The New York Rapid Transit Commission at its meeting on Dec. 31 agreed provisionally upon a new route for the road similar to that recently recommended by the Chief Engineer, Mr. W. B. Parsons, in that it adopts Elm St. instead of Broadway for the line from City Hall to 14th St.; but differing from the Parson's plan in that it proposes to continue the four-track construction north on Broadway and the Boulevard to 104th St., and omits entirely the line from 42d St. north on the east side of Central Park. The district to the north of the park, however, would be reached by a two-track road branching east from 104th St. and running up Lenox Ave. A two-track line from the City Hall to South Ferry is also included, and the total cost is set at $35,000,000 as an outside figure.

Public hearings are to be given by the Commission on the proposed plan before its formal adoption; and a good deal of opposition to it will probably develop among property-owners on the East Side. If they are wise, however, they will permit the Commission to go ahead and carry out its plans. It seems to be generally accepted that as a matter of financial prudence a part of the system should be built first, and when this is once in operation there will be no trouble to secure the building of such extensions as may be needed to complete the system.

With the renewed discussion of the rapid transit system the old talk of a "deep tunnel" system to be built "on the Greathead plan" has been revived by its former sponsor, "The Evening Post," and the editors of some of the other daily papers have taken the matter up, forgetting that this scheme was thoroughly gone over by the Rapid Transit Commission years ago and the impossibility of any deep tunnel system was at that time fully set forth.

The advocates of a deep tunnel system base their claims for it on the idea that it would avoid all difficulty with foundations, an idea which is, of course, ridiculous to an engineer. We may very briefly point out that a shallow subway, which requires no excavation below the foundation levels of the buildings on either side, could not at all affect their stability. A deep tunnel in the sand which underlies lower New York would threaten the stability of every building along its course, and no contractor would dare undertake it and assume the risk of damages which it would involve. On the other hand, if a tunnel were to be carried so deep as to be in the rock, it would be so far below the water level as to make its driving very dangerous and its success problematical. Besides all this, a deep tunnel railway requiring elevators to reach it could not begin to accommodate the traffic that the New York Rapid Transit Railway must handle.

One or two papers which have fought the enterprise from its inception are reviving the old talk that no one would ride on a railway underground and that elevated roads represent the ultimate perfection of city rapid transit. The real facts concerning this claim can be set forth as follows: If a four-track rapid transit railway is to be built on a street, we must make a two-story street and put the tracks above or below. If we put them above, we convert the street itself into a tunnel and the noise of the trains is an intolerable nuisance. It is far better, therefore, to put the railway below, and avoid all injury to owners of adjacent property. As has been before pointed out, the passenger on a railway close to the street surface will descend half or a third as many steps to reach his train as he now climbs to reach an elevated railway platform. In view of the electric underground railways of Boston and Buda Pesth, it can by no means be said that New York's subsurface road will be an experiment.

The experience with the tonnage system of rating locomotive performance, which is summarized at some length on another page, indicates that in this system there are opportunities to our railways for working economies in operating expenses which will rank favorably in importance with any of recent development. Broadly considered, it will be seen that this summary of experience with the tonnage rating system separates itself for all practical purposes into two divisions, methods and results. Under methods come (1) the determination of the hauling capacity of the locomotive, (2) make-up of trains, and (3) manner of recording results. To determine the hauling capacity of locomotives, it is generally conceded that no method is better than an actual road test, in which is determined the load that each class of engine, working to its full capacity, under favorable conditions, can haul over each division and grade. As to the making up of trains, there is less uniformity of practice, and, in a large measure, a tendency to "guess" methods, particularly in obtaining a knowledge of the weight of the car and its contents. In this respect, more strenuous efforts toward systematic and careful methods of weighing and billing freight and systematic allowances for tare and empty cars, are comparatively easy solutions, and should be sought. When, however, the question of reduced ratings for bad conditions of rail and weather is reached, the realm of variables is entered, and until the experimental knowledge of frost, wind, loading and other effects is more complete, it would seem that arbitrary systems must be adopted and tested to a working success in actual traffic. In the methods of measuring results, however, lies in a very large measure the success which will accrue from the tonnage rating. This is because the economies of greatest moment, and economy in fuel consumption particularly, depend very largely upon the diligence, carefulness and live interest manifested by the train men. A system of records should, therefore, be adopted which will appeal directly to the train men in terms which show to them the savings and losses resulting from good and from bad work respectively. The system should also be such a one that the train men have confidence in its fairness to all, and such a one as will allow of results and comparisons being posted in the roundhouse and yard as a reminder to the men of the success or non-success of their endeavors.

Turning now to the results obtained by using the tonnage rating, it is evident that in these lies the reason for its adoption, if there be any reason, and for such results we must consult the records of experience. Thus far these records show, generally, a decrease in fuel consumption per ton of freight hauled, larger and more uniform train loads, fewer trains hauled, and, as far as evidence exists, no inordinate increase in locomotive maintenance and repair expenses. When all is said, the duty of a locomotive is to earn revenue for the railway operating it, and the greater the ratio of paying to non-paying load which a locomotive hauls and the nearer to its maximum power that this locomotive is constantly worked the greater is the income earned by it. To such extremes does the American railway manager carry this principle, that our locomotive boiler practice suffers—as our English cousins are very fond of pointing out—in fuel consumption, compared with that of many foreign railways. But these excesses in fuel expenses are the seed sown to produce the maximum tractive power which fattens the engine revenue, and it is because of this very thing in no small measure that American freight service is the best and cheapest in the world. It is along these very lines that the tonnage rating system acts for economy by bringing about heavier car loads and fewer trains, and working the locomotive constantly at its full capacity.

The very simple method of testing the rate of setting of cement, which is suggested as having a possible development by Mr. Wm. S. MacHarg, in our correspondence columns this week, seems to us to be deserving of investigation. Our opinion is not based entirely upon the evidence and argument presented by Mr. MacHarg. Partly at our suggestion, this test has been applied to plaster of paris stucco at the works of the Mackolite Fireproofing Co., at Chicago Heights, Ill., and by means of a hastily devised dynamometer recording device the variation in power required to tear the cord from the paste appears as a diagram in which the time appears as the ordinate and the force of the pull as the abcissa. Only a few diagrams have been made at the time this is written, and although they are somewhat crude, owing undoubtedly to crudeness in the operation of the recording device, they give promise of furnishing a valuable basis of comparison for securing a uniform and constant product in the manufacture of stucco. It may be noted also that the physical appearance of the tear or fracture in the stucco tests corresponds closely to that for cements as shown in the photograph. In the event that some of our engineering college laboratories may be inclined to carry this system of testing to the ultimate proof of its usefulness, it may be suggested here that a cord with little stretch, such as a catgut or silk leader, should be used, and the pull should be applied continuously by clock work. With careful attention to elimination of the personal element and variations in influence of friction, etc., it would seem that a series of observations might be secured which would throw additional light upon the process of setting in cements even if a test of practical value for use by engineers were not developed.

THE TERMINALS OF THE BROOKLYN BRIDGE RAILWAY.

Perhaps no one subject has been discussed more exhaustively in the columns of Engineering News than that of the terminals of the cable railway which crosses the Brooklyn Bridge. In 1887, when the first steps were taken toward devising plans for something better, more economical and affording greater carrying capacity than the original tail switching system, we presented at great length the various plans proposed and adopted, and the reports and arguments thereon. In 1890 and 1891 again we dealt with the re-adopted plans and the various questions in connection with them. In 1894 and 1895 we described the construction of the New York and Brooklyn terminal stations and in 1896 we described the new method of switching by electricity to supplant the method of switching by steam locomotives, which has been in use since the opening of the railway in 1883.

Those of our readers who have been long on our subscription lists will recall that for several years

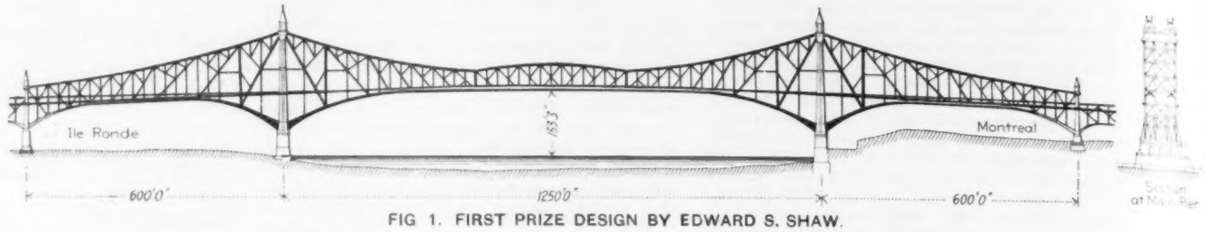

FIG. 1. FIRST PRIZE DESIGN BY EDWARD S. SHAW.

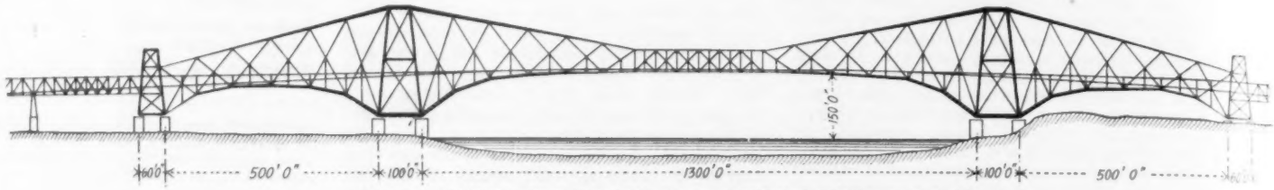

FIG. 2. SECOND PRIZE DESIGN BY A. L. BOWMAN, ASSOC. M. AM. SOC. C E.

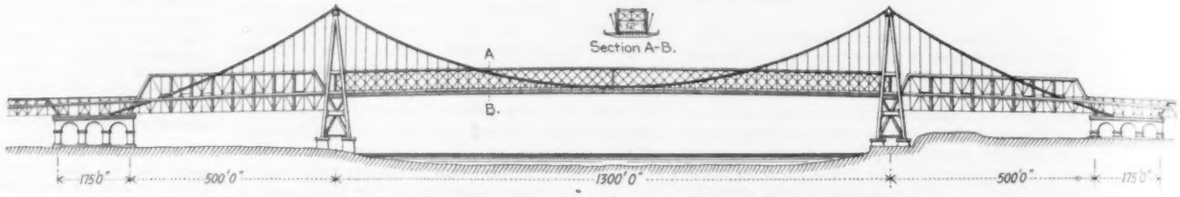

FIG. 5. DESIGN BY C. C. WENTWORTH, M. AM. SOC. C. E.

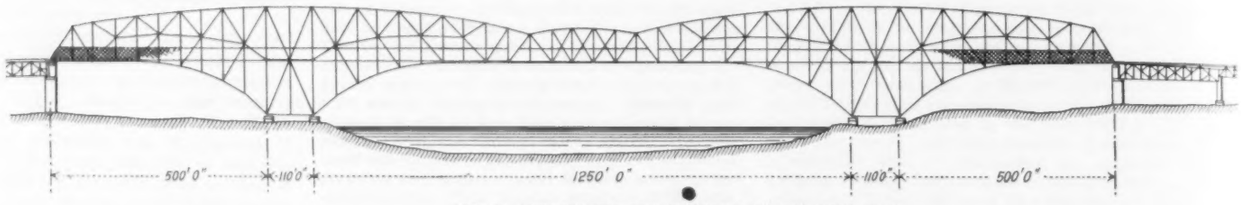

FIG. 6. DESIGN BY JAS. RITCHIE, M. AM. SOC. C. E.

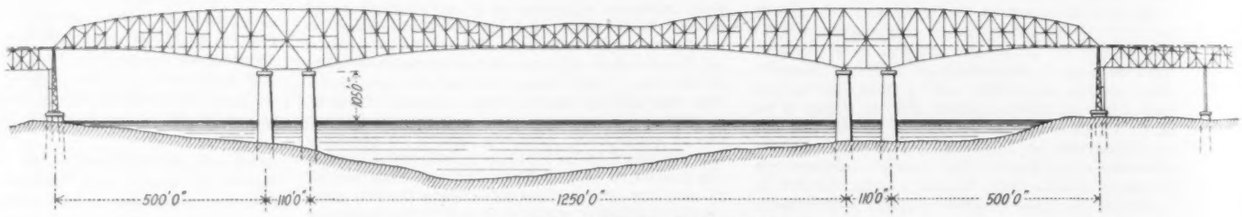

FIG. 10. DESIGN BY C. J. WELCH.

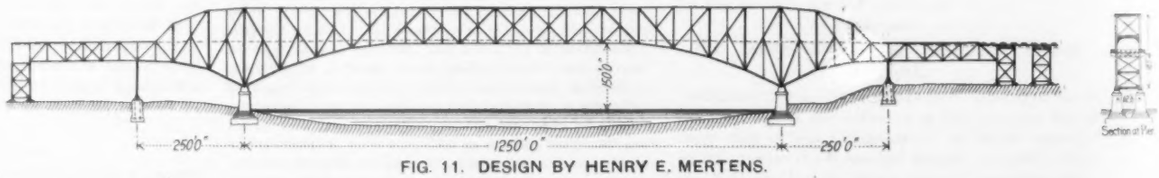

FIG. 11. DESIGN BY HENRY E. MERTENS.

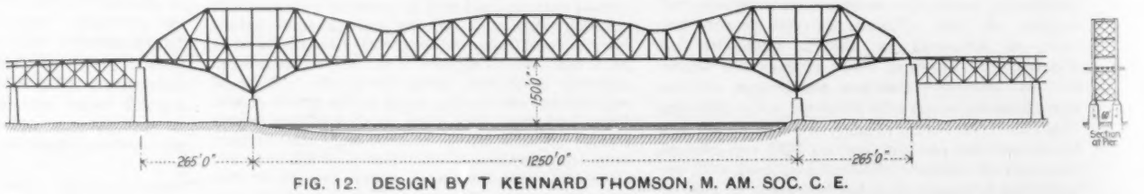

FIG. 12. DESIGN BY T KENNARD THOMSON, M. AM. SOC. C. E.

COMPETITIVE DESIGNS FOR A BRIDGE O

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C. N. ARMSTRONG, Managing Director.

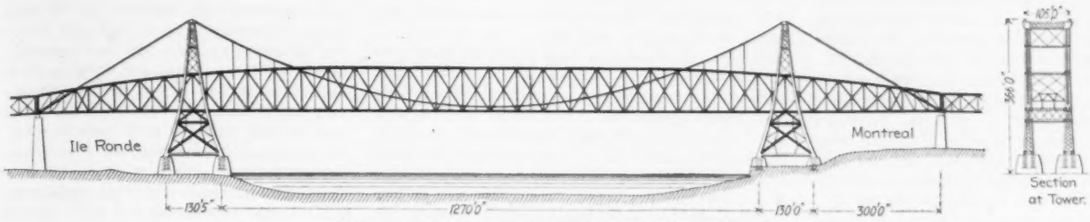


FIG. 3. SPECIAL PRIZE DESIGN BY J. W. BALET.

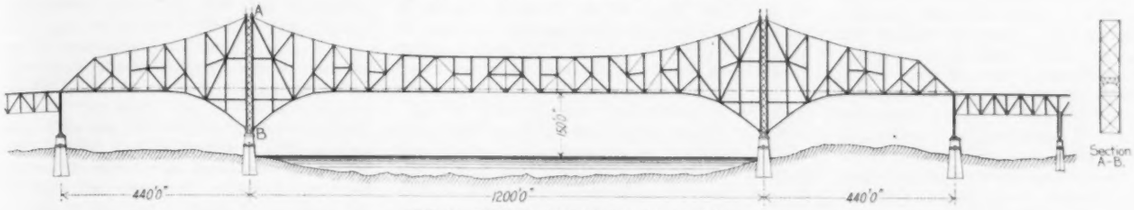


FIG. 4. DESIGN BY HENRY SZLAPKA.

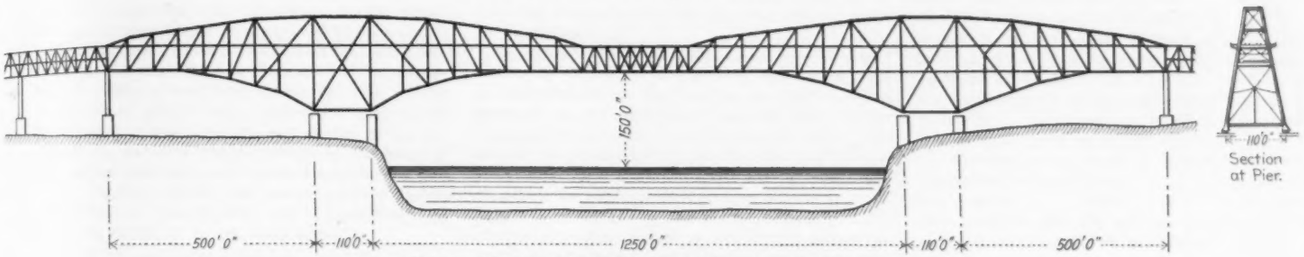


FIG. 7. DESIGN BY CHAS. H. WRIGHT, M. AM. SOC. C. E.

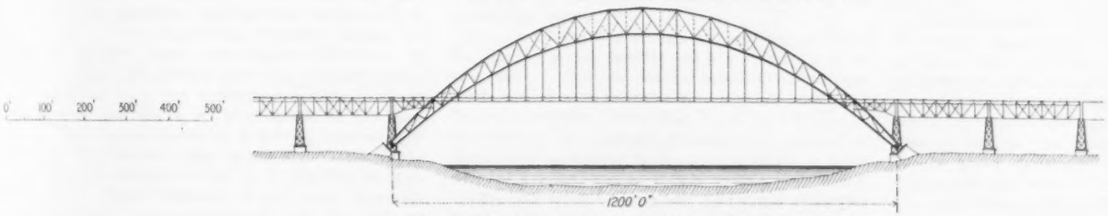


FIG. 8. DESIGN BY C. R. GRIMM, M. AM. SOC. C. E.

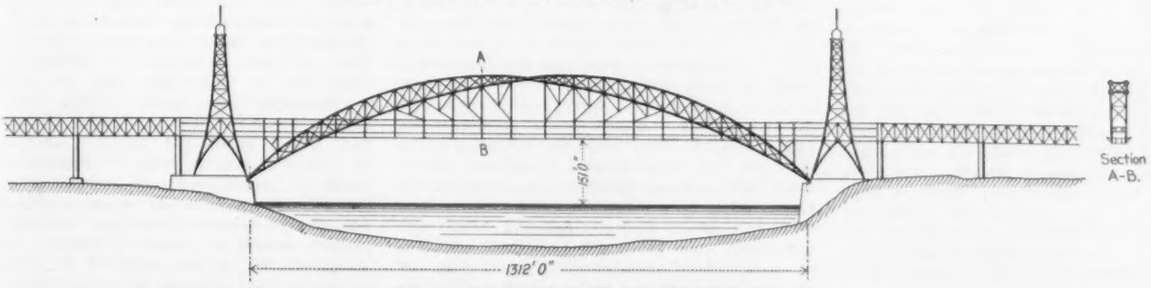


FIG. 9. DESIGN BY FRANCOIS BICHEROUX.

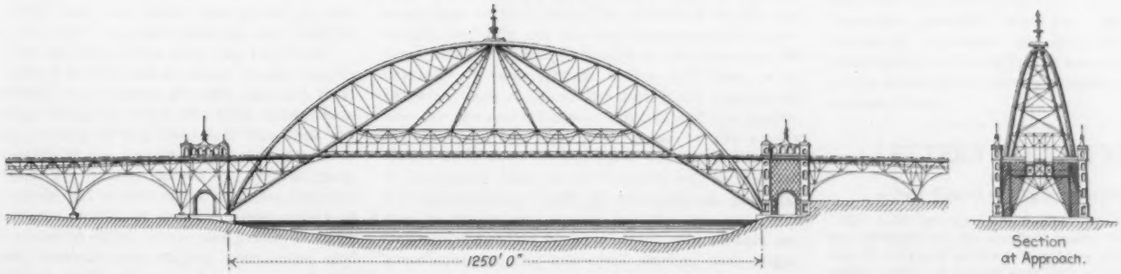


FIG. 13. DESIGN BY CHAS. STEINER.

DGE OVER THE ST. LAWRENCE RIVER AT MONTREAL.

tted to the Montreal Bridge Co.

WALTER SHANLY, M. Can. Soc. C. E., Consulting Engineer.

there appeared on our editorial page in the first issue of each year a note concerning the status of the Brooklyn Bridge terminal improvements, and will remember also that it was repeatedly stated in these columns that the plan of terminal improvement adopted by the trustees in 1891 would give no material benefit in the way of decreasing the headway between trains. In view of the fact that the present year is to see this plan of terminal improvement put into actual operation, we again devote space in this first number of the year to this subject, for it is a remarkable illustration of the fact that the success or failure of a given engineering design or of a great engineering work is dependent on details, and that the alteration of a single detail may entirely change the solution of an engineering problem.

The Brooklyn Bridge railway was opened for traffic in 1883, and the number of passengers carried by it in that year was, in round numbers, 5,000,000. This was increased to 8,000,000 in 1884, 17,000,000 in 1885, and 24,000,000 in 1886, and an urgent demand arose for an improvement in train service. With the system of operating then (and still) in use, it was not possible to increase the length of trains above four cars, nor was it possible to decrease the interval between trains, which was in the rush hours substantially 90 seconds.

In April, 1887, the bridge trustees employed Mr. Chas. E. Emery, M. Am. Soc. C. E., "to devise proper means of switching trains," and on receipt of his report elected him a consulting engineer of the bridge. A plan was devised by him which involved the use of a grade-crossing at the head of the station platform, over which loaded trains had to be switched. This plan was severely criticised in our issue of June 4, 1887, and the criticism was generally taken up by the daily press.

The bridge trustees, instead of carrying out Mr. Emery's plans, as they had at first proposed, then referred the question of terminal facilities to a board of experts, consisting of Messrs. Julius W. Adams, Walter Katte, and Joseph Crawford. In March, 1888, this board reported, recommending the adoption of a loop system, according to plans devised by the late A. M. Wellington, M. Am. Soc. C. E. The bridge trustees, however, rejected this system and instead voted to adopt a "tail switching" system devised by Mr. C. C. Martin, M. Am. Soc. C. E., Chief Engineer of the bridge since its construction. Nothing, however, was done toward carrying out these plans until a year later, in May, 1889, when the trustees again formally adopted the same plans with some minor modifications. Legal obstacles in connection with the condemnation of land intervened to stop progress for another year, and meantime a considerable public sentiment developed against the carrying out of the plans which had been condemned, in their general principles at least, by a board of expert engineers. In deference to this sentiment the whole question of terminal facilities was finally referred to a second board of experts, consisting of Messrs. Samuel Spencer, C. W. Buchholz and Geo. W. Plympton. This board reported in January, 1891, approving the plan of Mr. Martin. The six years which have elapsed since that time have been spent in constructing the new terminal stations, and making the other alterations which that plan involved.

As we stated above, and as many of our readers will remember, this journal strongly opposed, from its inception, the plan which has been carried out. The chief ground of our objection was that the grade-crossing at the rear of the station platforms over which all trains have to be switched, would prevent the reduction in the time interval between trains, which it was the chief object of the Martin plan to effect. Over this grade-crossing every train entering the station must pass; and the switching engine without the train must also pass over this crossing once for every train that enters the station. The bridge trustees and their engineers claimed that with this system of operation, it would be possible to run trains in 45-second intervals, and even at 40-second intervals. This journal held that under actual conditions of train movement it would not be possible to move trains and locomotives with any such frequency over this crossing without serious accidents. But which of the two were right will probably never be settled by the test of experience to which we appealed as the final arbiter, for while the Martin plan is to be put in operation probably early in the present year, trains will be switched under it, not by steam locomotives, but by electricity. By equipping the first car of every train with electric motors, each train has been made self-propelling, and as the switching engines are dispensed with the number of movements over the grade-crossing is halved, and it will be as easy to operate on 45 seconds headway as it would have been on 90 seconds headway with the locomotives. In fact it will be easier, for the electric motors start the trains much more promptly and thus economize the time necessary for switching.

No one who discussed the subject in the years from 1887 to 1891, when it was under consideration, foresaw this solution, so far as we know, and it certainly was never put forward publicly to meet the objections which were brought against the Martin plan. But it has admirably met these objections, and, so far as we can see, will enable this plan to accomplish all that was claimed for it by its advocates.

The extended advocacy of the loop system of terminals by this journal, however, has borne fruit in other directions. Six months ago the Brooklyn Elevated R. R. completed a loop terminal for its trains at the Brooklyn Bridge station, and a loop system has been adopted for the suburban service of the great new Boston railway station, the plans of which we shall publish in our next issue. It has, in fact, become a well-settled principle of engineering, that to handle a very heavy passenger traffic at a terminal station, a loop is the best possible system, and should be adopted wherever the conditions permit.

The new Boston station just referred to is to be a great union station in the southern part of the city of Boston, Mass., accommodating the traffic which now uses the Kneeland St. and Park Square terminals of the New York, New Haven & Hartford R. R. and the Kneeland St. station of the Boston & Albany R. R. It will occupy a great area of ground, and as it will have a very heavy traffic, particularly from the numerous suburban lines to the residence towns and villages which surround Boston, more than ordinary care has been taken to so arrange the station and its tracks as to give the greatest possible facilities for train movements and passenger accommodation. The plans have been prepared largely under the direction of the officers of the N. Y., N. H. & H. R. R. The station is "double-decked." The upper level, somewhat above the street level, is for main line service, and has 28 parallel tracks with intervening platforms, as in ordinary practice. The lower level, slightly below the street level, is for suburban traffic, and has two loop tracks connecting with the four-track approach, there being thus two incoming and two outgoing tracks. Since no switching will be required, and there will be no interference between the tracks, and no backward movement of the trains, the suburban trains will be able to follow one another very closely, the platform being of sufficient length to accommodate 40 cars (20 on each track). There will thus be no blocking back of the traffic during the busy hours because the arrival tracks are full and the incoming trains must wait until some of the empty trains have been hauled back out of the station. It is assumed that electric traction will be adopted for the suburban traffic by the time the new station is ready for service, as the use of steam locomotives would be unpleasant and almost impracticable in the low-level station with slight headroom. The four suburban tracks will be on an easy grade, and the upper and lower level of the station will be reached from the street by easy inclines so that no steps will be necessary. The middle or island platform will be the loading platform, and the two side platforms will be for unloading, as in the system proposed by Mr. Wellington. The adoption of the loop system in this case has been specifically for the purpose of facilitating the handling of a great number of crowded trains during the morning and evening "rush" hours.

Returning now to the Brooklyn Bridge it is to be noted that despite the fact that a new terminal system is just about to be put into use after ten years of agitation, a third board of experts is now wrestling with a problem more important than any that have been considered with reference to that structure in former years.

In all the discussion over the Brooklyn Bridge terminals which was carried on from 1887 to 1891, the sole object which all had in view who struggled with the problem was how to move long enough and frequent enough trains across the bridge to comfortably accommodate all the passengers that might come to either terminal of the bridge. Everyone was singularly blind to the fact that Brooklyn can never reap the full measure of its opportunity as the great residence district of Greater New York until it is possible for its railways to land their passengers on the other side of the East River without change of cars.

From this point of view all the work which has been done in the development of the Brooklyn Bridge railway as an independent link in the transit from city to city appears to be a mistake. Instead of building the great terminal stations at each end of the bridge it would be vastly more to the advantage of users of the bridge had the same money and energy been devoted to the construction of connecting tracks by which all the Brooklyn elevated trains would be enabled to run upon the bridge tracks. If this can be done successfully, the benefit to the public will be vastly greater than could result from any possible improvements to the bridge railway as an independent line.

As we have said above, a board of expert engineers is now investigating the feasibility of such a through system of transit. Without attempting to discuss the question in advance of the issuance of their report, it may be pointed out that the operation of trains by electricity on the Brooklyn elevated roads is a change which ought to be made both in the interests of the public and of the stockholders of the companies; and this change would much facilitate the handling of through trains over the bridge.

In our issue of March 17, 1888, and also in the report of the experts who at that time gave their opinion upon the matter of improved terminal facilities, was published a map of the cities of New York and Brooklyn, showing that whereas the former city has an area of but 9 sq. miles within a distance of 8 miles of the New York City Hall, the city of Brooklyn has an area of 64 sq. miles which is within the same distance from the same point. The importance of making this vast area easily accessible for residence purposes was then fully set forth. But the possibility of saving ten minutes of the time of every traveler between the two cities by carrying him through without change was strangely overlooked. If it was worth while to expend a million dollars and more, merely to carry passengers over the bridge railway without crowding, it is worth while to expend ten times that sum, provided such an expenditure were necessary, to secure the prompt transfer of all passengers on Brooklyn railways to the other side of the East River without change of cars and for a single fare.

LETTERS TO THE EDITOR.

A New Test of the Rate of Setting Cement.

Sir: Although the Vicat needles have for so long a time been accepted as the standard means for determining the rate of setting of cements, they have held that position because nothing so readily applicable and capable of showing more of the process of setting has presented itself, rather than because the needles were altogether satisfactory to investigators. This is evident from recent inventions intended to make a continuous application of this test by wheels or by needles operated through the whole time by clockwork. That this desire for some test showing more definitely and completely the process of setting is not of recent origin is shown by the following from "Portland

Cements for Users" (London, 1894), by the late Mr. Henry Faija:

It may be well * * * to decide on what is meant by the word set. In general the word is used to express a period when a substance originally in a liquid, semi-liquid or glutinous state, has attained the ultimate hardness due to its nature, and if it is desired to express an intermediate period, the qualification "sufficiently" is added. With cement, however, which may not attain its ultimate hardness for years, the word "set" has a somewhat different signification, and it is understood that a cement "sets" in a few minutes or hours, after which it hardens. The means usually employed to fix the period when the setting is completed and the hardening commences, are, in the author's opinion, rather at fault, inasmuch as it is the hardness of the sample which by the process alone is considered, either by pressing it with the thumbnail or by using a Vicat needle.

As previously stated, the setting of a cement is purely chemical in its action; it is commenced with the addition of the water to the cement, and continues until the cement has attained its ultimate hardness. Continuous, however, as this chemical action may be, there are periods, at all events, during the early stages that may be defined, and it would appear desirable to express by the word "set" one of these periods.

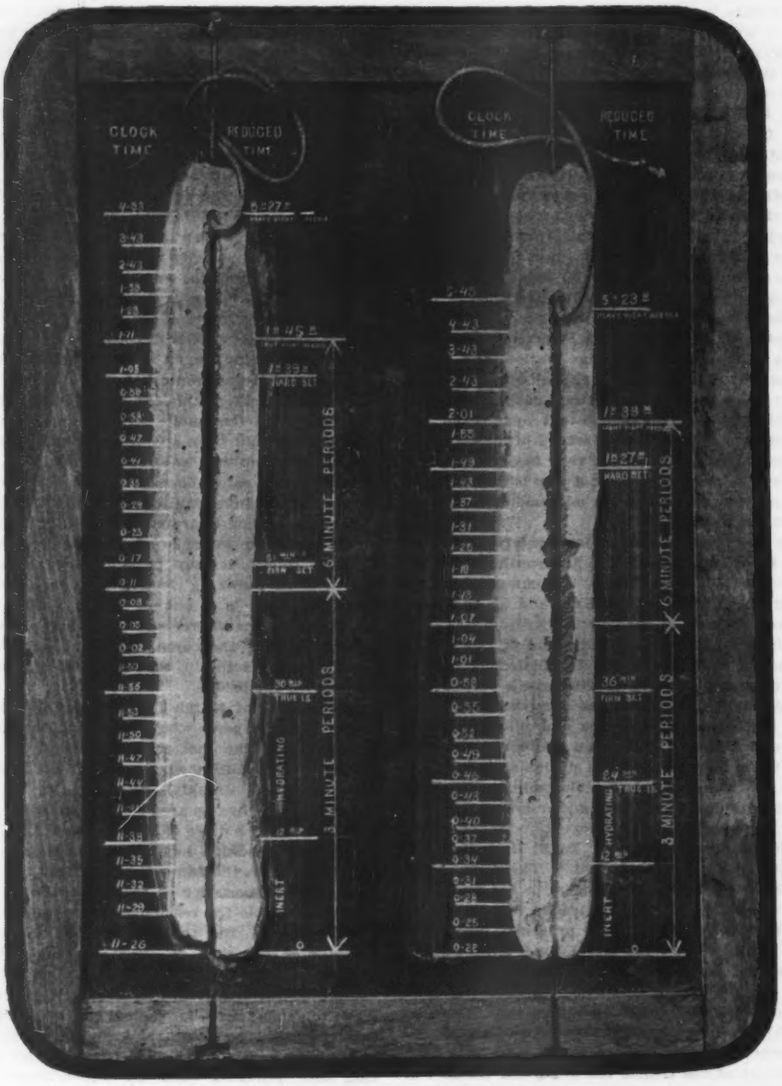
When a cement is gaged and made into a pat or briquette, the first change observable is that the water comes to the surface, the next that the water is absorbed by the cement, the sample will then begin to heat, and lastly, it will gradually return to its original, or what may be called, its normal temperature, and it is this last period that may with justice be understood by the word "set." It has nothing to do with the hardness, as some cements will be hard enough to withstand the impress of the thumbnail before, and some not until long after, the time when the author considers a cement "set."

I quote this at length as the best expression that I know of the process of setting in cement, the want of anadequate method of determination of periods in the same, and the actual relation of the Vicat needle test to the process of setting.

It is evident to any one who has studied the subject, that most or all Portland cements, subjected to the ordinary test, have set a distinct and considerable time before the light Vicat needle is perfectly supported, that is, supported without a mark. This makes necessary the exercise of judgment as to the real activity of a cement, which it is desirable to eliminate, both as a cause of difference of opinion and to secure uniformity of method. In the above quotation Mr. Faija has indicated a period and a means of its determination much more nearly correct, but the fixing of the time of total absorption of water from the surface of a pat, while it may be done, still requires the use of judgment, and persons may differ materially in what they consider total absorption.

The explanation given by Mr. Faija of the process of setting, and his selection of the period when the cement may be considered set, are satisfactory. The same period, however, is fixed by the definition that "a cement is set when the mass no longer admits distortion without fracture," and this, I think, is the true definition. This condition, also, being a distinct stage in the progress from paste to eventual hardness, admits the application of a mechanical test for its determination. From this conclusion I sought a mechanical test, easily applied, and devised that shown in the cut, which, from its simplicity, and the clearness with which it shows all the physical characteristics of the cement in sequence, during the time of its application, may, I think, prove valuable.

An ordinary school slate is used, notched at opposite ends to hold a flexible cord, which is stretched across so as to lie on the surface of the slate. Cement paste, made by adding 25% of water to clear cement, well worked, is then plastered over the cord as shown, covering it a little more than its own diameter, and trowelled smooth. Marking at one end of the pat the time the trowelling is finished, the cord is loosened at this end, and at periods of three minutes is gently lifted from the cement in spaces ¼-in. to ⅜-in. long, marking the space and time at the side as shown. After the cement has set the periods of time are lengthened (the spaces remaining the same length), to six minutes, then twelve minutes, and finally to much longer periods, so that the whole may be completed in the length of the slate. The result is eminently satisfactory; in the hardened cement is recorded every phase of the process of setting, and the periods of change may be determined very closely.



A NEW METHOD OF TESTING THE RATE OF SETTING OF CEMENT.

In the example shown in the cut, for the purpose of illustration the test by the Vicat needles also is carried on, and the test by the cord is continued until the heavy needle is perfectly supported. It is to be noted that the true initial set, or time when fracture commences, occurs more than an hour before the light needle is perfectly supported, in both instances. The cements used in this test were both of American manufacture, one being a true Portland, and the other a so-called natural Portland.

Referring to the cut, four stages in the early setting of cement are distinctly shown, each with characteristic markings; (1) an inert period, during which the particles are apparently arranging themselves for the coming change and the cord lifts as out of semi-liquid mud; (2) a period of hydration, while the water is being absorbed, during which the cord lifts, as from stiff mud without cohesion; (3) a period of mild set, or initial set, with perfect cohesion, during which period the cord brings away the cement with definite and clearly marked fracture, usually involving some width of the pat; (4) a period of hard set, when the cord comes away with a much shorter fracture of the cement, making a narrower groove in the face of the pat. In the second sample in the cut this characteristic change in the fracture is very plainly shown, but in the first also, and in the several tests I have made, this change is distinctly marked. With a quick-setting cement tried in one experiment, the third period was found to be extremely short.

The beginning of the third period is determined by this method, agrees very closely with the conditions pointed out by Mr. Faija as denoting the occurrence of initial set, and I think this should be taken as the time of initial set. The condition of the mass at the beginning of the fourth period may indicate that this is the point at which commences that final chemical process which we know as the "hardening" of cement.

It is evident that by the application of a train of clockwork this test may be made automatically and continuously. Affairs forbid that I should take the time necessary to establish the relations which may exist between the periods shown in this test, and the qualities of cements, but I hope that the experiment may be tried by others more directly interested in this material, and I shall be pleased if the method is found of value.

Wm. S. MacHarg,

Chicago, Ill., Dec. 23, 1896.

Notes and Queries.

C. H. C. asks: Can momentum be accumulated?

Certainly it can. Our correspondent is probably confusing mass or inertia with momentum. The latter is the product of the mass of a body by its velocity. Hence, if a body is being accelerated, it is accumulating momentum.

D. G. M., Baltimore, Md., asks whether the automatic bucket for coal hoisting at the Oakland docks of the Southern Pacific Ry. (Eng. News, Dec. 17) would load itself in broken stone, loaded in barges. The stone is broken to a size to pass through a 2½-in. ring.

We do not know that any of the grab or clamshell buckets of this type have ever been worked in material so hard to penetrate as broken stone, and doubt whether they could be made successful. If any of our readers have had experience in this line we should be pleased to hear from them.

"New York Harbor" asks us to give an approximate estimate of the cost of dredging, in "soft bottom," an open ditch, 20 ft. deep, with the bottom of the ditch 65 ft. below mean low water. The depth specified is so much below the limit of usual dredging contracts and so much depends upon the nature and amount of the material to be excavated, that an answer is difficult. In the case of the new Buffalo breakwater, proposals for which were recently opened, the specifications require the dredging of a trench in mud. This mud deposit averages 38 ft. deep, and the bottom of the mud stratum, or the rock, lies from 60 to 77 ft. below the water surface. The estimated quantity of this trench excavation is 565,000 cu. yds., and the bids for making this excavation range from 18 to 33 cts. per cu. yd. The full table of bids was published in our issue of Dec. 31, 1896, and the work was described and illustrated in our issue of Oct. 29, 1896.

AN ORIGINAL DEFINITION OF A COFFER DAM is given by the "Buffalo Enquirer." In describing the work on an Erie Canal contract near Buffalo, it says:

"Some of the most important machines are the coffer dams, a kind of floating dam to protect the men from the storms which so suddenly spring up these days."

RECENT DEVELOPMENTS IN RATING LOCOMOTIVE PERFORMANCE.

Within the last year or so the traffic and motive power departments of American railways have been devoting an unusual amount of study to the problem of developing a better system of rating locomotive performance. As a result of this study the long-used system of rating a train load by the number of cars has been superseded on a number of important railways by the tonnage rating system, in which the load hauled is expressed in terms of tons of actual load. This so-called tonnage rating system is in no way a new one. As a matter of fact it has been used for years, but not so commonly as the car rating system. For many railway men it has, however, an element of novelty, and evidence in relation to its inherent advantages and practical operation is sought with considerable interest. Unfortunately, such evidence is not so plentiful as could be wished, and such little as exists is widely scattered and in inconvenient form for reference. It is for these reasons that the attempt has been made here to summarize the more important records of experience and the most practically valuable opinions of those who have studied the question.

In making this summary we have deemed it most convenient to present, first, a general consideration of the subject in the form of an abstract of a paper just read before the Western Railway Club by Mr. Tracy Lyon, Master Mechanic, Chicago Great Western Ry. We have divided the paper under several headings, and under the same headings present the practice of other railways for the purpose of comparison. All the information presented has been based upon papers and discussions printed in the proceedings of the Western Railway Club, the North Western Railway Club and the New England Railroad Club during the years 1895 and 1896. It has been the purpose not to repeat experience, and, therefore, general expressions of opinion which simply confirm explicit statements already given here have been omitted. The following is the abstract of Mr. Tracy Lyon's paper:

Locomotive Rating and Fuel.

It has been our experience that the maximum capacity of locomotives over the various grades can only be determined satisfactorily by means of a series of actual tests under favorable conditions, these tests being made with a carefully weighed train with frequent observations of the speed of the engine, steam pressure, and cut-off. In making such tests the stops usually necessary in service must be taken into consideration, as their location, as affecting the run which can be made at a hill, governs in many cases the load which can be carried over it. A theoretical determination of the capacity upon any basis of the computed traction of the engine and the resistance of the train would seem to be entirely unreliable, from the number of physical conditions which of necessity enter into the problem, these conditions consisting of all possible combinations of grades and curvature variously affected by the location of stations, bridges, crossings, and switches, as well as the quality of the track. We have found that satisfactory results are obtained by basing the maximum efficient traction, which can be developed at low speeds, upon a mean effective pressure in the cylinders of 80% of the boiler pressure. The capacity of one class of locomotives over a certain part of the road having been determined by test, that of another is easily, and, by our experience, satisfactorily obtained by such a simple comparison of their traction.

As to the train resistance, we find that 6 lbs. per ton fairly represents the wheel resistance of a loaded car under ordinary conditions, to which is to be added the grade resistance and the resistance of curves, which is too indeterminate a quantity to say much about, but is sometimes placed at one-half of a pound for each degree of curvature. After having determined the capacity of the locomotives over the principal grades in each direction, it will be found necessary, assuming that the road under consideration is an average one as far as physical conditions are concerned, to divide it into a series of blocks or sections with reference to the ruling grades, location of stations and other fixed points, each one of these sections representing a different rating. An independent series of sections will, of course, have to be made for each direction, their terminals only coinciding of necessity at division points.

In determining the limits of these sections there is to be considered: The location of their terminals at points where it is possible and most convenient to drop and pick up cars; the termination of a section when the rating is to be decreased, at a sufficient distance before approaching a hill to obtain such a run at the latter as will permit the maximum load to be carried over it (the importance of increasing the load over a ruling grade and thus increasing the rating of the through train, even at the expense of decreasing the limits of a greater rating, enters here) and the making of the sections as long as possible without too much of a sacrifice in the average rating. With us these sections vary in length from 6 to 75 miles.

Make-up of Trains.—The weight of each carload, both car and contents, is first inserted in the waybill by the agent. Fractions are not used, less than 1,000 lbs. being dropped and over 1,000 lbs. counted as one ton. This information is shown on the switch list used by the yardmen in making up the train, empties being given an arbitrary weight, according to the class of car. The weight of the cars and contents in the train, having been inserted in the conductor's report, is certified to by the agent and this information is sent at once to the dispatcher. At all stations where cars are picked up or dropped, the conductor enters their weight upon his report and also wires it to the dispatcher. One of the principal difficulties to be met with is the making of proper allowance in the weight of the trains for unfavorable conditions of rail and weather. To the discretion of the dispatcher who receives a telegraphic report of the weather and condition of rail from all stations twice a day, is left the decision as to whether a train shall be made up to first, second or third rating, the yardmaster having standing orders to load all trains to first rating in the absence of other instructions. There are certain exceptions, however, in the case of fast time freight and stock trains, which uniformly receive second or third rating.

In arriving at such a classification we have made certain assumptions which would seem to be borne out by practice. To the total train resistance in pounds per ton, obtained by dividing the traction of a certain engine by the maximum load or first rating, is added 2.4 lbs. and the loading or rating corresponding to this increased resistance represents the second rating for that engine, that is to say, for an inferior condition of rail and weather. To obtain the third or still inferior rating, representing the most unfavorable conditions ordinarily met with, we add 4.4 lbs. to the train resistance corresponding to the maximum rating. This method would seem to have an advantage over that of making a horizontal reduction in the rating of a certain percentage, in that it decreases it in a proportionately less ratio as the tonnage decreases.

For a train composed entirely of empty cars, a further reduction of 10% is made in the rating; if only one-half the cars are empty the reduction is 5%, and other proportions in the same ratio. These figures are based upon the assumption that the wheel resistance per ton of an empty car is one-third greater than that of a loaded car, or as 8 lbs. are to 6. The practice of increasing the weight of an empty car to allow for empties in making up the tonnage of a train is sound in principle, but objectionable if it is desired to obtain the actual tonnage.

Recording Results.—After all has been said, the sole object in view is to run the trains with as few engines as possible and if they haul as near the maximum loads in one direction as the conditions will permit, the other direction will take care of itself. We, therefore, measure our performance by the amount of the train wages per ton-mile in the direction of the greatest traffic. This is the key note of the whole thing. A daily statement is made giving the tonnage of every freight train, upon which is shown the actual cost of the train wages per 100 ton-miles in the direction of greatest traffic, as compared with what these wages would have been per 100 ton-miles if the full rating had been hauled. A separate statement is made for each division in order to compare the work of different men.

Train Load.—Since the establishment of the tonnage rating system on the Great Western Railway in January, 1894, the increase of cars per train has been 3.8, or about 21%. This, however, is not a full measure of the benefits derived, as during the corresponding period the average tonnage for a loaded car has also increased by about 15%. As a net result, the weight of the average train, as compared with that before the tonnage rating went into effect, has actually increased by about 40%, in spite of the fact that many more fast trains, and consequently lighter ones, are being run now than previously. This result is further borne out by the corresponding earnings per freight train mile, which have increased in the same relative ratio.

Fuel Consumption.—For convenience we have adopted as a unit the coal consumed per 10,000 miles of total train, including the weight of the engine and tender, and the consumption varies under the same weather conditions from 0.5 ton to 1.2 tons per 10,000 ton-miles for different trains, divisions and directions.

The measurement of coal on the engine may first be considered, almost all roads lacking facilities to accomplish this accurately. We have in use for loading coal both buckets and chutes and in some cases load directly from a car or dock. Where buckets are used either directly or to fill the chutes, platform scales are provided and a sufficient number of buckets weighed each day to enable the men to fill them with a fair degree of uniformity, usually to 1,000 or 1,100 lbs. We have experimented with various forms of spring scales hung above the bucket, but so far they have proved too inaccurate. The contents of the chutes are gaged by their cubical contents and the weight per cubic foot of the coal used, which is determined by measuring and weighing a considerable quantity of coal in bulk. Where the coal is shoveled directly from the dock, the number of scoops is counted. I find that considerable dependence can be placed upon the judgment of the men who handle the coal and that they soon become able to make very close estimates.

To check these figures to a certain extent, we have established a standard location for the back coal boards and gates on all classes of tenders and determined by weighing what the capacity of each class of the latter is as usually loaded. Each tender is marked with a row of rivets on the center line of the side of the coal pit, indicating the number of tons contained when the coal is shoveled into the back of the pit and leveled off with its top, which is done upon the arrival of an engine at a terminal.

Inasmuch as one crew does not run continuously on the same engine, it is necessary to consider each trip by itself in order to obtain each man's record separately.

When an engine leaves the roundhouse, the engineman is given a slip showing the amount of coal on the tender, he enters upon this slip the amounts he takes at intermediate points (which are checked against the tickets turned in by the coal men, and delivers it to the roundhouse foreman at the end of the trip. The latter measures the amount of coal in the tender on arrival and enters all these items on his daily report of engines "in." There is also shown on this report the time the engine is idle under steam or switching before and after coaling and the amount of coal with which it goes out.

This latter amount is arrived at by adding to the amount on the tender upon arrival the amount taken at the terminal. These amounts are checked as soon as received and entered upon a sheet containing the record of one train for a month. Upon this sheet are shown the total ton-mileage of each train, the consumption of coal, and the number of hours idle under steam and switching on that trip (obtained from the train sheets as well as the roundhouse foreman's report), and, finally, after deducting an allowance of 50 lbs. of coal per hour for being idle under steam, and 500 lbs. per hour for switching, the net consumption of coal, which is comparable with the work done. The allowances referred to some times do not amount to very much, but they are valuable in their moral effect in assuring the men that their records are true. The amount of coal accounted for in this way usually comes within 1% to 2% of the amount charged as received.

In order to be able to compare the work of men on different trains and divisions, we have established a basis of allowance in tons of coal per 10,000 ton-miles for each class of train in each direction and on each division, this allowance having been arrived at by a long series of experiments and records of amounts consumed, and representing not the average, but the best performance which could be expected under favorable conditions. On the performance sheets, which are posted monthly in the roundhouse, are shown, opposite each engineer's name the amount of coal he used during the month, the amount allowed him (based upon the ton-miles made and the class of service performed), and the percentage of excess of the latter over the former. The performance of the men is therefore measured by this percentage, and if they have used less than the allowance, which is not an unusual thing in the summer, the percentage is shown in red—a very enviable distinction.

I do not believe in the premium system; it too often results to the advantage of a few men only and has very little interest for the rank and file. With a consistent method of comparison, the good men take care of themselves; it is the laggards who need attention. Very little can be accomplished by declaring that everything is bad, but if the weak points can be isolated, they can soon be wiped out.

In Fig. 1 I have shown the cost of coal per train mile, the miles made per ton of coal and the coal used per 10,000 ton-miles for all classes of trains, both freight and passenger, for a period of eighteen months. It will be seen that while the coal per ton-mile represents a fairly uniform curve, the train miles per ton vary at times without apparent reason.

We consider it best not to make any changes in the allowances for even the extremes of weather, preferring that there should be established for the relation between the actual consumption and the base, what might be called a curve of temperature. The increase in consumption of coal per ton-mile during the winter months would seem to be about 25% of that consumed during the summer. It will be noticed that there is a marked decrease in the amount of coal consumed per 10,000 ton-miles, as compared with that consumed during similar periods of the previous year, this decrease amounting to about 24%, which we think fairly attributable to systematic and consistent methods of keeping account of the coal.

It must also be considered in this connection, that the weight as well as the speed of trains, has been gradually increasing during the period covered, which accounts for the fact that the cost of coal per train mile has decreased to such a slight extent. This is especially noticeable in the passenger trains, the average consumption of coal per ton-mile of passenger trains over that of freight trains, having increased from 28 to 45%, in consequence of changes in schedules made within the last few months.

The additional expense incident to this work is represented with us by the cost of the stationery needed and by the wages of two clerks, whose entire time is devoted to tabulating the reports and getting out the performance sheets, and possibly a helper at roundhouses where the force is already at the minimum point, in order that the coal may be properly shoveled into the pit of the tender.

Hauling Capacity of Locomotives.

Evidently the first work of a railway about to adopt the tonnage rating is to determine, as a basis for records and comparison, the actual tractive force or hauling capacity for its locomotives. A multiplicity of variables enter into this problem. Concerning the role played by some of these variables the available knowledge is entirely speculative. The roles played by others can be approximated from existing information. Only by an exhaustive series of tests can the information be made complete and exact, and it is at least an open question if, after such tests are made, the results will not still show so many variables as to make their practical value small. These being the conditions the determination of the hauling capacity of locomotives as a working basis for a tonnage rating must be, in a large measure, an arbitrary determination for each particular railway. To some, perhaps, the lack of exactness and scientific analysis in this method of procedure will not appeal favorably, but let these persons first consider what it means to obtain the data necessary for scientific analysis, and then remember the multiplicity of varying conditions to which these data must be applied in actual practice. It will take only a few minutes thought to pile up a complication of variables, the determination and integration of whose separate and combined influences upon the hauling capacity of locomotives would be an enormous labor of experiment and analysis.

Having examined the reasons for using actual hauling tests, the method of making them is next to be considered. Two methods have been practised: (1) Determining by actual test, with a locomotive in good condition and working to its full capacity, the weight of train which can be hauled over each division and grade under favorable conditions. (2) By using a dynamometer car. The second method possesses some advantages in accuracy over the first, but the first method has been more commonly used, mainly for the reason that so many factors enter into train resistance under even the most favorable conditions that any at-

tempt at extreme accuracy is simply a waste of time, and the most that can be done is to obtain a result that will accord with average conditions. Experience has shown that this result can be obtained by hauling tests, and in the following matter the methods and results of such tests are given:

In 1895 the rating of locomotives on the Great Northern Ry. was changed from the train to the tonnage system. Mr. H. H. Vaughan, Mechanical Engineer, assumed the total tractive force of his locomotive to be expressed by the formula,

$$T = \frac{d^2 \times s \times p}{D},$$

where D = tractive force, d = diameter of cylinders, s = piston stroke, p = boiler pressure and D = diameter of drivers, all quantities being in inches and pounds. In this formula it was assumed that the boiler pressure was effective during the entire stroke, and that there were no losses of power due to the supply of steam being cut off, to back pressure during exhaust, nor to friction. Calling T the total tractive force it is evident from the assumption that the actual tractive force will be less than T. Mr. Vaughan reasoned that when conditions were known it might be regarded as a certain percentage of it for all similar cases.

He divided resistance to traction into train resistance, grade resistance and curve resistance. Grade resistance was taken as being the same proportion of the weight of the train that the rise of the grade is to its length. Curve resistance was taken as ½-lb. per ton per degree of curvature, and train resistance as 7 lbs. per ton. The resistance of a train weighing W tons, running on a grade of G per cent. and on a curve of C degrees would thus be W (7 + 2 G + ½ C) pounds. If the weight of the train is known, that a given locomotive can haul on a certain grade, the percentage of the total tractive force developed can be deduced. Conversely if the total tractive force is known the load that can be hauled at a uniform speed on a given grade can be obtained.

To determine the load hauled Mr. Vaughan obtained the weight of the train in a number of instances in which engines in good condition were known to have been worked to their full capacity with fully loaded trains, and from this deduced the percentage of the total tractive force that might be actually developed by the engine. It was considered that practically the only source of error was that due to the allowance for train resistance, and that even this was to a certain extent neutralized, when the grades to which such results were applied were not greatly different from the grade taken as a basis of calculation. If, for instance, the correct figure for train resistance should be 6 lbs. per ton, instead of 7 lbs., and the weight of the train had been taken on a 0.6% grade, then the error arising in the calculation of the loads that should be hauled on other grades would reach a maximum of 9¼% for a level; while for a 0.2% grade it would be 7¼% and for a 1.5% grade it would be 2.7%. Mr. Vaughan considered that to secure complete accuracy dynamometric tests should be perhaps carried out, but that there were so many factors entering into the resistance of a train, even when the same weight was carried in the same number of cars, that any attempt at extreme accuracy was simply a waste of time, and the most that could be done was to obtain a rating that would accord with average conditions.

The series of observations made led to the adoption of the following ratings: 80% for long, steep grades where the locomotives are worked hard for a considerable time and the limit is imposed by the rate at which coal can be burned if the fire is to be kept in proper condition; 85% on grades not exceeding five or six miles in length or on long grades where the quality of coal used will admit of more rapid firing; 90% on undulating track where the maximum power is only required for short distances and sometimes on long grades where coal and water are especially favorable; 92% where the limiting grade is short and the majority of the line easier.

With these ratings of uniform speed and favorable conditions of weather, track, etc., are assumed, but in practice there must be considerable unfavorable conditions of track and weather and the surplus of energy due to velocity, or kinetic energy. (The allowances for bad weather, bad track, etc., properly come under the heading of Make-Up of Trains and are given in that place.—Ed.)

In allowing for the utilization of kinetic energy Mr. Vaughan considered the simplest method to be to assume a definite speed which could generally be reached in service. At this speed the kinetic energy of the train was capable of lifting its weight a certain height, and if that is applied, the amount of work exerted by the locomotive in lifting the train is diminished by such a height. The height assumed for actual use was 15 ft. at the speed of 21 miles per hour. In making allowance for speed in practice the total rise of the grade can be obtained from the profiles: 15 ft. is taken from the rise and the remainder divided by the length of the grade, giving a reduced grade upon which loads can be calculated on the assumption of constant speed. An equivalent profile is thus obtained for any section of road which is often different from the actual one. Mr. Vaughan advises that no allowance for kinetic energy be made when the total rise of the grade exceeds 100 ft. to 120 ft.

On the Chicago & Northwestern Ry. the rating of locomotives for the Minnesota and Dakota divisions was changed from the train to the tonnage system in 1895. To determine the hauling capacity of the locomotives, a locomotive of the largest class used was taken with a train of known weight over a division and back again. The train used was greater than the locomotive could haul, and a helper-engine was taken along, by means of which the number of cars was added to or decreased in such a manner as to keep the hauling locomotive working to its full capacity. Careful records were kept of speed, boiler pressure, cut off, load, etc., and from these the hauling capacity of the locomotive determined. Smaller locomotives were tested in the same manner, and their hauling capacity determined in percentages of that of the largest locomotives.

The tonnage rating was adopted on the Minneapolis, St. Paul & Sault Ste. Marie Ry., on May 1, 1895, and the hauling capacity of each class of locomotives, between each station on the several divisions, was based on the actual weight of train that a locomotive in good condition, worked to its full capacity with all conditions favorable, had previously hauled.

Make-Up of Trains.

A primary essential in the make-up of trains is an accurate knowledge of the weight of each car and its contents. Not a great deal of explicit information appears regarding the various methods of obtaining this knowledge, and it is generally admitted by railways using the tonnage rating that more strenuous efforts to secure accuracy and uniformity are necessary. A report presented by a special committee of the Western Railway Club says, regarding this point:

The actual weight of the contents of the car should always appear on the way bill. Agents often bill unweighed bulk freight at minimum car load weights, almost regardless of the actual weight of the contents. Where actual weights cannot be obtained, agents should be trained to estimate them as closely as possible. Present practice results in general over-rating. Actual weights of empties containing tare of various kinds should be used. Empty stock, refrigerator or other cars often contain large amounts of refuse matter, ice and other substances which make them in fact partially loaded cars. Systematic methods of treating such cars as partially loaded should be worked out. The tare in these cars will vary on different divisions of the same road and often on the same division.

The hauling tests being made under favorable conditions of rail and weather, it becomes necessary to allow for cases in which the conditions are unfavorable to the locomotives developing its maximum capacity. In other words, a reduced rating has to be adopted for unfavorable conditions of weather and rail. This is accomplished by reducing the train load a certain per cent. of the maximum rating, the percentage of reduction depending upon the severity of the conditions. Some railways quite rigidly limit the use of reduced ratings by definite rules and methods, while others leave the matter very much more to the discretion of the yard masters or train men. Generally speaking, the more rigid regulation would seem to be preferable as it places the responsibility upon the persons best fitted to use it, although, of course, conditions will arise when the discretion of the train men must be permitted. In these cases, however, a strict accounting should be required of the trainmen for any action taken by them. It is a noteworthy fact, however, that where the tonnage rating has been the best developed, the train men do not shirk heavy trains, but prefer to pull the full capacity of the locomotive, since, by so doing, their record on the performance sheet is improved.

It follows, therefore, that the second essential in the make-up of trains is the determination of a schedule, or system, of reduced ratings for unfavorable conditions of weather and rail. For the Chicago Great Western Ry. this system of reduced ratings has been explained. Other examples of practice are as follows:

On the Great Northern Ry., the reduced ratings for different conditions of weather and rail are as follows:

Fast trains scheduled at 18 to 20 miles per hour..	10%
Frosty or bad wet rail.....	7%
Freezing to zero.....	15%
Zero to 20 below zero.....	20%

On the Minnesota and Dakota divisions of the Chicago & Northwestern Ry. only one reduction of 10% is made for unfavorable weather, leaving the balance to the train men, and requiring them to notify the dispatcher by wire of the circumstances for which cars are set out to reduce the train.

Recording Results.

The method of measuring results on the Fitchburg R. R. is described by Mr. John Medway, Superintendent of Motive Power, as follows:

A suitable form is furnished the division superintendents, who supply the following information: Train number, locomotive number, name of the engineman, extent of run and weight of train. These are forwarded daily to our office, where the report is completed by the addition of the total number of pounds of coal consumed and pounds of coal used per ton of load during the trip. We personally scrutinize these reports and forward them with our criticisms to the road foreman of locomotives, who give each specified case proper attention, not forgetting a word of commendation to those who make particularly good records.

It is interesting and somewhat surprising to note the wide diversity of scores made under apparently similar conditions. Prompt investigation frequently reveals the cause of a bad fuel record, and it is fair to say that it is sometimes beyond the control of the engineman; possibly a load of inferior coal, slippery rail, "stalled on the hill," helped train ahead, local work, or an engine failure. Of course the latter condition is occasionally aggravated by a sin of omission on the part of the engineman. We have found cases wherein locomotives have made several expensive runs, wasting perhaps two tons or more of coal each trip, when proper search has located a mechanical disorder which formerly might have been ignored, so long as the locomotive did fairly good work. Under the new order of things the engineman is on the alert for all causes detrimental to good, economical service. In this connection the fireman receives proper attention at the hands of the engineman, who, perhaps, for the first time, assumes a positive control of the entire locomotive outfit. Admitting the possibility of the best men making an occasional bad run, the same is not adversely recorded, but should a man make a succession of bad performances, the case is marked for drastic treatment.

In order to determine the quantity of coal consumed per trip, the coal tickets, which are of the usual book form with stub and coupon, were made to show the amount of coal found on tender, as well as the added supply. In computing the quantity used for a stated trip, the amount found on tender, plus that delivered at all points, less the quantity left over at the end of the trip, is charged against the engineman. Positive accuracy in the last item is desirable, though not readily attainable, but to enable the coal charger to estimate the quantity of coal found on the tender, a vertical scale of half-ton spaces is placed in white paint on the tank, at the front end of coal space; this insures a fair degree of accuracy.

We prepare and post monthly a list of the individual general averages of pounds coal per ton of load. This is intensely interesting to all concerned, and provokes a sharp rivalry on the part of the men. In order to demonstrate more clearly than ever the possibilities in the direction of either economy or extravagance and to show the relative value to the company of careful, economical men, as against those who have proved themselves unprofitable, we supplement the circular with a comparison of the extreme scores, reduced to a basis, which appeals most forcibly to the reasoning faculties of the average mortal—that of dollars and cents. For example, we quote from the April report: "Comparing the worst with the best individual general average of this division, and preserving the same ratio for a month of 25 days, we find in this single instance a possible loss to this company of $202.76." We endeavor to show our appreciation of the efforts of the many successful men, and on the other hand spur to greater exertions the less fortunate ones; while the few continuously unprofitable men are informed that a prompt and radical change is necessary to justify the continuance of their services.

Train Loads.

On the Minneapolis, St. Paul & Sault Ste. Marie Ry., according to E. A. Williams, Superintendent of Machinery, the increase in loaded cars hauled during the first six months use of the tonnage rating was 1.44. Mr. Wm. McIntosh (Chic. & No'wn) states that, with the tonnage rating the road is hauling more freight and other parties are better satisfied with the operating officials and engine men. Mr. E. L. Brown (St. P. & Dul.) states that, previous to adopting the tonnage rating, they were handling 40 loads between St. Paul and Hinckley, and 35 loads between Rutledge and Duluth. Since adopting the tonnage rating this record has been increased to 45 loads and 40 loads, respectively. Mr. C. H. Quereau (B. & M. R.) states:

As an illustration of the way the tonnage rating has affected the loading of engines, on one division where the terminal point is approximately in the centre of the division, the average loaded freight train was about 16 cars previous to the use of the tonnage rating. But the first month after the tonnage rating was put in force, and since then, the average number of loaded cars on his freight trains has been over 19, or an increase of almost 20%. The same thing is true on other divisions. On one division which is some 700 miles long and has few branches, the number of trains has been increased, though not in quite so large a per cent., and that has been the result everywhere on the system. This, of course, conduces to a better fuel performance, and as a result, partly of this and partly of other measures, our fuel consumption has improved considerably.

As the result of five years use of the tonnage rating, Mr. J. H. McConnell (Union Pacific) says:

Five years ago when we commenced increasing our train haul, or increased the service of our locomotives, we found the train haul for the year 1890 averaged 15.86 cars. In 1891 we had increased it to 16.11 cars; in 1892 to 16.85 cars; in 1893 to 17.12 cars; in 1894 to 18.96 cars, and for the year 1895 it will average about 21.88 cars to the train, for the same engines.

In 1890 the cost of hauling a loaded car one mile, that is including all the expense of the locomotive and car departments, was 3.17 cts, over the entire system. In 1891 it cost us 3.05 cts.; in 1892, 2.84 cts.; in 1893, 2.79 cts.; in 1894, 2.65 cts.; and in the month of October, 1895, it costs us 2.01 cts. to haul a loaded care one mile.

Showing the result of a systematic effort in the train haul on the Wyoming division last year, we will take one month. In the month of September, for instance, we handled 80,558 cars in 1894, and 79,942 in 1895. There was a decrease of 616 cars handled on that division, a mountain division. Our train miles in 1895 decreased 44,000 miles, and we ran 484 less trains and handled only 616 cars less. The number of cars to the train hauled on the Wyoming division in September, 1895, was 27.95 cars; and September, 1894, it was 22.50 cars. That was an increase of nearly 5½ cars per train, with the same engines. We did that by putting helpers at different points along the line of the road where we could help the trains over the hill. Where we were pulling 28 to 30 loads with one engine, by the assistance of a helper on some of the grades the train haul was increased in a number of instances to 45 loads. In 1894 we ran 89,509 trains; in 1895 we ran 82,056, a decrease of 7,453 trains. The freight train mileage was 7,155,000 miles in 1895, and 7,742,000 miles in 1894, a decrease of about 586,000 miles. The car mileage in 1895 was 190,287,000 miles, and in 1894 was 196,839,000 miles, a decrease of 6,000,000 car miles in 1895. While our engine mileage in 1894 was

10,108,000 miles, in 1895 it was 8,760,000 miles. There was a decrease of 3.3% in our car mileage, a decrease of 7.4% in our train mileage, a decrease of 8.3% in the number of trains run, and a decrease of 13% in the engine mileage.

On the Nebraska division (which we call a level division, because it has only a rise of 5,000 ft. in 516 miles), in 1895, the average earnings of the freight engines was $50,676, and they averaged 25.80 cars to a train. It cost us to operate each locomotive in freight service $9,369, leaving the net earnings of each and every locomotive on the Nebraska division $61,307. On the Wyoming division, where we have to run helpers, we have figured the helpers in with the freight engines, and each engine there earned $53,918.09 with a cost of $11,357 for operation, leaving the net earnings of each engine there $42,560. Now this has all been accomplished by an increase in our train haul, and a systematic way of doing it. In 1894 it cost the Union Pacific Co. $1,040,000 less to haul their freight cars than it did, comparing the same number in 1890—all due to the increased service from the locomotives, and to no other cause. The cost per mile for locomotive performance for the last six years was: In 1890, 26.45 cts.; 1891, 26.16 cts.; 1892, 25.96 cts.; 1893, 26.19 cts.; 1894, 27.48 cts.; 1895, 25.03 cts.

Fuel Consumption.

On the St. Paul & Duluth R. R., according to C. D. Brooke, Master Mechanic, the consumption and cost of fuel for six months of 1895, with the tonnage rating, compared as follows with similar figures for 1894, when the train rating system was used:

Month.	Lbs. of coal per car mile. 1894.	1895.	Cost of coal per car mile, cts. 1894.	1895.
July	3.04	2.68	0.50	0.40
August	2.95	2.99	0.49	0.45
September	3.36	2.90	0.55	0.41
October	3.33	3.68	0.55	0.52
November	3.90	4.20	0.66	0.63
December	3.89	4.07	0.64	0.61

On the Minneapolis, St. Paul & Sault Ste. Marie Ry., according to E. A. Williams, Superintendent of Machinery, the coal consumed by locomotives for eight months of 1895, while rating engines on the tonnage system, as compared with the same months of 1894, when the train system was used, showed a net saving of $16,807, or about $2,100 per month. The cost per car mile for hauling freight cars in 1894 was 1.18 cts., and in 1895 it was 1 ct.

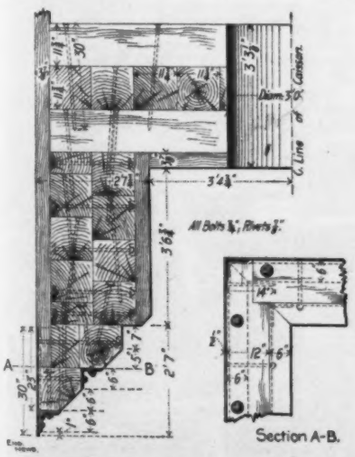


Fig. 3.—Details of Cutting Edge of Caisson.

Few other definite records of fuel saving are available, but among others the following railways have stated through some of their officers that the tonnage rating had resulted in a saving of coal: Chicago, Burlington & Quincy; Fitchburg, Chicago & Northwestern; Union Pacific; Chicago, Milwaukee & St. Paul, and Burlington & Missouri River.

PNEUMATIC CAISSON FOUNDATIONS FOR THE GILLENDER BUILDING, NEW YORK CITY.

The great weight of the lofty office buildings which are now such a feature of modern construction in New York city, makes the design of the foundations a very important matter, and the difficulties of properly distributing the loads are in most cases increased by the comparatively limited area available for the foundations. We illustrate this week the interesting foundation work of the Gillender Building, recently erected at the corner of Wall and Nassau Sts. This building consists of a cellar and 19 stories, with a cupola of two stories in addition, the total height above the sidewalk being about 280 ft. It covers a lot only 25 × 75 ft. The style of construction is the steel cage system, made up of four columns extending to the top of the 17th story and eight columns to the top of the 19th story. The cupola is cylindrical, with a spherical dome surmounted with a lantern and flagstaff.

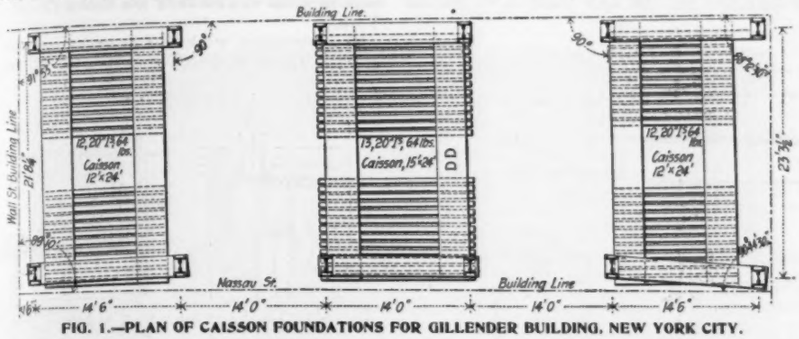


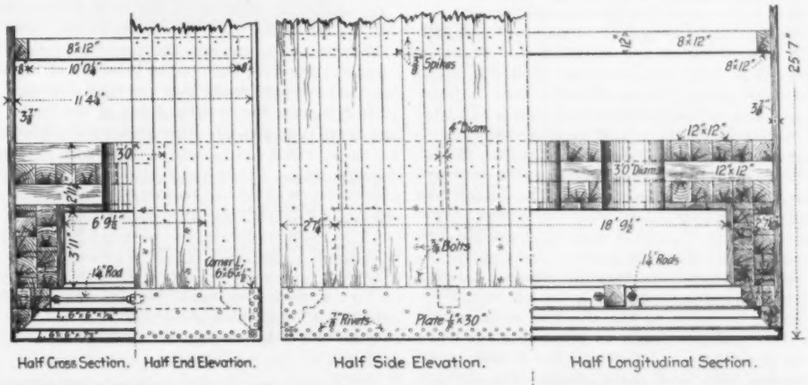
FIG. 1.—PLAN OF CAISSON FOUNDATIONS FOR GILLENDER BUILDING, NEW YORK CITY.

The two columns at each end of the building carry about 650 tons, the four columns adjoining them carry about 750 tons, and the central four columns are loaded with about 950 tons.

Investigations of the site showed that the material was a dangerous quicksand, extending to a considerable depth, and underlaid by a good, reliable stratum of hardpan, upon which the foundation might safely be based. In order to pass through the quicksand and to avoid such a disturbance of that material as might lead to settlement or injury of adjacent buildings, it was decided to adopt the pneumatic caisson system. The caissons are of yellow pine, with steel cutting edges, and were sunk to and bedded upon the hardpan. The air chambers were filled with concrete. Above the roof of each air chamber is a pier of brick laid in Portland cement, extending up to the bottom of the steel foundation grillage, and leveled off under the I-beams of the grillages with about 12 ins. of concrete. The I-beams and cantilevers were painted and then coated with coal tar, the whole being covered with a minimum of 12 ins. of concrete, and filled solid inside the girders with Portland cement grout for protection from corrosion. The grillage on top of each pier is composed of 20-in. I-beams, weighing 64 lbs. per ft., surmounted by two heavy box girders, upon the ends of which rest two transverse box girders which form the seats for four columns of the superstructure. The depth from new cellar line to bottom of caisson is about 42 ft. for the caisson at the Wall St. end, and 40 ft. for the caisson at the back end of the building, the cutting edges being sunk about 2 ft. into the hardpan.

As shown in Fig. 1, there are three of these caissons and piers, each extending across the entire width of the building. Two of the caissons are 12 × 24 ft., and one is 15 × 24 ft., each of the former containing 27,864 ft. B. M. of timber, and the latter containing 32,323 ft. B. M., or 88,051 ft. B. M. in all. The total amount of ironwork included 300 screw bolts ¾-in. diameter and 21½ ins. long under the head; 1,000 drift bolts, ¾-in. diameter and 30 ins. long, and 5 kegs of ⅝-in. wrought iron spikes 7 ins. long. The material used is all yellow pine, and the timbers are thoroughly fastened together by screw bolts and drift bolts. The construction of the caissons is shown in Figs. 2 and 3.

Around the site for each caisson sheet-piling was driven into the sand at the surface, and braced by inside rectangular frames of square timbers, the caisson being sunk in the enclosed space. Above the top of the caisson proper was an open cofferdam to hold back the excavation. This was composed of a top and bottom frame the size of the caisson, with 6 × 6-in. vertical sticks and 1-in. vertical rods, and sheathed with 2-in. horizontal planking. When the caisson was finished and the ironwork was in place this was removed and the space was filled in with concrete. The construction of the grillage work of the foundations is shown in Fig. 4. The working chamber and locks were filled with concrete, the upper part of the caisson was filled with brick masonry, and concrete was filled in around the ironwork over the caisson.



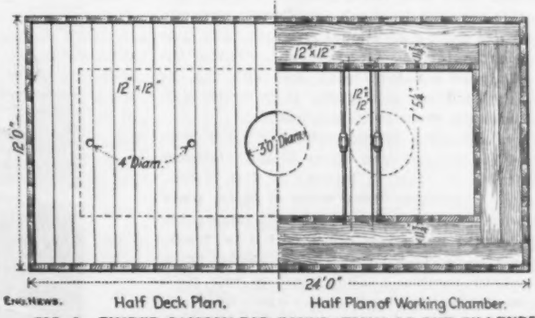


FIG. 2.—TIMBER CAISSON FOR FOUNDATIONS OF THE GILLENDER BUILDING.

The caissons are designed of sizes such as to load the ground about 12 tons per sq. ft., and are located on the line through the center of gravity of the weights on the columns. This brought the two outside caissons nearer the second pairs of

columns from the ends, the middle caisson being on the center line between the four middle columns. The use of wood for the caissons was decided on as most economical and convenient, and the subsequent experience during construction confirmed the wisdom of the choice. The timber used was planed on all sides to exact dimensions, and was framed and bored before delivery at the site. The outside planking was vertical and was greased to diminish the skin friction.

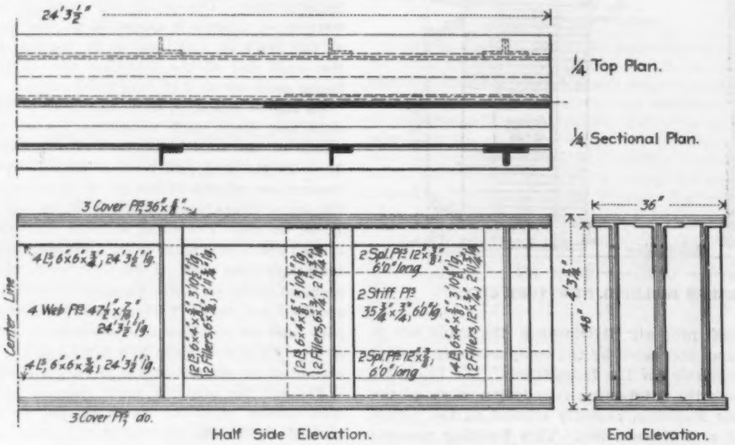


FIG. 5.—DETAILS OF BOX GIRDER FOR FOUNDATIONS.

All the caissons were sunk to place without difficulty or accident of any description. The time employed in doing the work was divided in about three equal parts of a month each, viz.: 1, Shoring and underpinning with steel columns and joining walls; 2, Building and sinking caissons; 3, Sheet piling, excavating, setting grillages and cantilevers, concreting and completing the masonry underpinning of adjoining walls. The actual time required in sinking the caissons was 7 days for the caisson 15 × 24 ft., and 4 days each for the two caissons 12 × 24 ft., the remainder of the month being employed in constructing the caissons, building the brick piers and concreting the air chambers. The space occupied by the site was so restricted that there was practically no progress made while trying to combine underpinning and caisson work or caisson work and sheet piling. The attempt to do this resulted in much additional confusion and expense and no additional progress. The contractors estimate that with favorable weather instead of almost constant rains, and with the experience gained on this work, they could sink such caissons to place in 48 hours each.

The underpinning of the adjoining walls consisted of 14 wrought iron tubes 16 ins. diameter and 40 to 45 ft. long, in lengths of 4 ft. 6 ins., with 6-in. couplings. They were of ⅜-in. plate iron, lap welded and machined for butt-joints; the bottom lengths being reinforced with 1-in. inside rings, and the top lengths with ½-in. outside rings machined to receive a 24-in. square cap with ribbed socket fitting closely and planed inside at the bearings. Chambers, 20 ins. square, extending up 10 ft. from the bottom, were cut in the walls to receive the pipes and two old crusher plates of chrome steel were set at the top of these chambers to jack against, these plates being 12 × 28 × 5 ins. Hydraulic jacks of 60 tons capacity were used and a ¾-in. jet from a 1½-in. pipe was supplied by a duplex Worthington pump of 2-in. suction and 1½-in. discharge. A pressure gage on the pump usually indicated 50 lbs.

When the tubes reached the hardpan, about 100 tons pressure was applied until after several trials it would simply compress under the loading and return to its former height when relieved. It having been thus ascertained that they were of themselves able to bear the load to be imposed the tubes were then cleaned out and concreted. Brick masonry was then laid on the top of the cap, filling the chamber in the wall, and steel wedges between cast plates were built into it. After a couple of days, when the cement had set sufficiently, the wedges were driven until the weight on the foundations was transferred to the tube. At first the wedges were placed under the plates at the top of the chamber, but this was found to be too far from the tubes, and thereafter they were placed about 2 ft. above the caps of the tubes. It then appeared that the only function left for the plates at the top of the chamber was as an abutment for the jack, and in one case these plates were omitted without any difference in the behavior of the wall, so that in sound walls they are superfluous.

Fig. 5 gives the details of one of the heavy box girders (D D, Fig. 1). It is built up as follows:

	Section, —ins.—	Length, ft. ins.
6 cover plates	36 × ⅝	24 3½
4 web plates	47½ × 7-16	24 3½
4 web stiffeners	3½ × ¾	6 0
8 splice plates	12 × ⅜	6 0
4 filler plates	12 × ¾	2 11¾
8 filler plates	6 × ¾	2 11¾
8 angles	6 × 6 × ¾	24 3½
16 angles	6 × 4 × ⅝	3 10¾

The girders are noticeable for the enormous amount of riveting, and the rivets at the seats of the girders and columns have countersunk heads.

Fig. 6 is a general view of the work, showing one of the cofferdams and the top of an air-lock. These air-locks were made by the Cockburn Barrow & Machine Co., of Jersey City, N. J. The air compressors were furnished by the Rand Drill Co., of New York, and the wrought iron tubing for supporting walls was made by the Crane Co., of New York.

The foundation work was designed and carried out by Messrs. Stephens & O'Rourke, 44 Broadway, New York, to whom we are indebted for blueprints and photographs. Messrs. Berg & Clark, of New York, are the architects. The steel superstructure was designed by Mr. Henry Post and was built by Post & McCord. It is considered to be one of the best examples of steel cage construction, both as to design and execution, that has ever been built. Mr. Charles T. Wills is the general contractor.

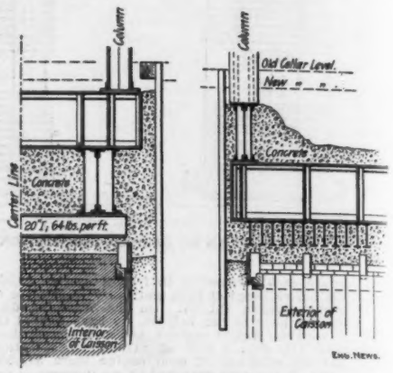


Fig. 4.—Half-Sections through Grillage and Box Girders at top of Foundations.

AN ELECTRIC SWITCHING LOCOMOTIVE.

We illustrate herewith an electric locomotive which is in use at New Haven, Conn., for hauling freight cars between the main line of the New York, New Haven & Hartford R. R. and a number of factories along the river front. The road is owned jointly by several large manufacturing concerns, and is about two miles long, having numerous sidings at the different fac-

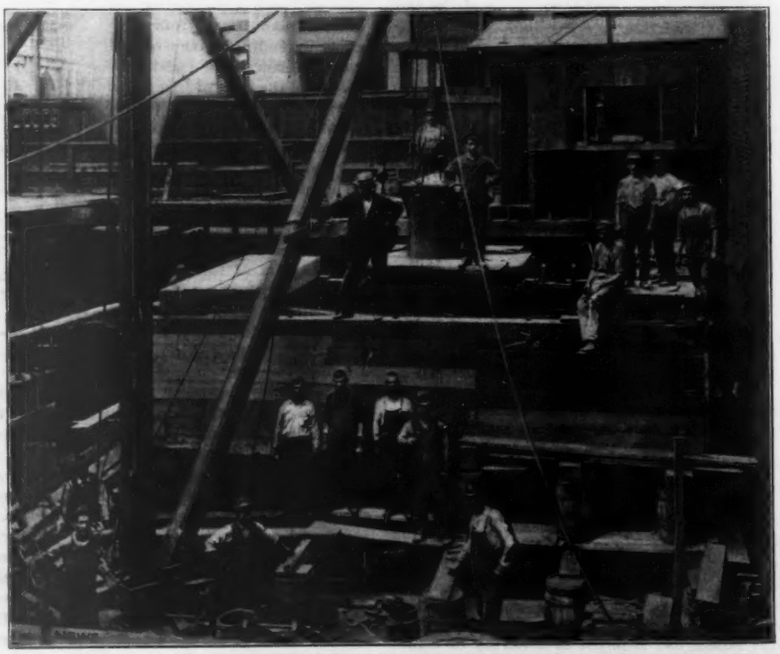


FIG. 6.—VIEW OF AIRLOCK AND COFFERDAM AT FOUNDATIONS OF THE GILLENDER BUILDING, NEW YORK CITY.

tories. There are numerous curves and the maximum grade is 2½%. The track is of substantial construction. Formerly the cars were hauled by horses, but this was so slow and so hard on the horses that mechanical traction became desirable. Steam traction was objectionable, as the line follows a frequented highway for some distance, and the engine would be standing idle under steam for a considerable part of the time.

ELECTRIC LOCOMOTIVE FOR SWITCHING; MANUFACTURERS R. R., NEW HAVEN, CONN.

The electric locomotive shown herewith was built by the General Electric Co., of Schenectady, N. Y., and is guaranteed to haul two loaded freight cars up a 2½% grade at the rate of seven miles per hour. It has been in operation since Dec. 11. The general dimensions are as follows:

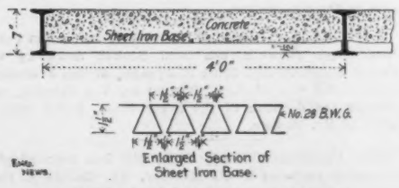
Wheels (4)	3 ft. 8 ins.
Journals	5½ × 8 "
Wheelbase	5 ft. 6 "
Weight	58,000 lbs.
Drawbar pull	7,000 "
Length over drawbars	16 ft. 6 "
Width over all	8 " 3 "
Height over all	11 " 6 "
Voltage	500
Amperes, full speed and normal drawbar pull	600

There is one gearless motor to each axle, the motors being supported by spiral springs seated on the side frames of the engine. The armatures are of ironclad construction, having the windings placed in a mica lined slot in the surface of the laminated core. The armature and comutator are upon a sleeve through which the axle passes, the sleeve resting in bearings on the motor frame. Two arms projecting from the sleeve fit into openings in an iron plate which is loose on the axle, and projections on the wheel engage with openings on the other side of the plate. Each motor has four brushes.

The cab contains the controller, automatic circuit breaker of 500 amperes capacity, lightning arrester, reversing switch, and air pump and motor for brakes. The resistances are in the shields outside the cab, and are of the ribbon-packed type. Sandboxes with pneumatic feeds are also placed in the shields. The air pump is controlled by a pneumatic governor, consisting of a cylinder containing a piston working against a spring. The piston-rod carries the contacts for the pump circuit. As the pressure rises the piston is forced upwards and the circuit is broken; as the pressure falls the spring forces the piston back and reconnects the circuit. The current is furnished from the Fairhaven & Westville power house, and is distributed by an ordinary overhead trolley wire. In a recent test the engine hauled six loaded cars up a grade of 1%, and only 150 amperes were required to start the train.

TEST OF THE BAILEY SYSTEM OF FIREPROOF FLOORING.

A test of the fireproof flooring system patented by Mr. Thomas Bailey, 501 West 151st St., New York city, was made by the Department of Buildings at the testing ground, 68th St. and Avenue A, on Jan. 5. The floor is a combination of a base of sheet iron supporting a bed of concrete, constructed as shown in the accompanying sketch. The test was made in one of the brick buildings which had been used in one of the earlier tests by the Department, the floor, 12 × 16 ft. in area, made in three panels, each 4 ft. wide, forming its roof. The 7-in. I-beams were placed 4 ft. apart c. to c., and on their lower flange was laid a flooring of sheet iron, No. 28 B. W. G., bent into the shape shown in the sketch. The sheets before bending are 32 ins. wide, and when bent the width of each piece is about 11 ins. Adjoining sheets overlap so as to make a substantial joint. Above this base of sheet iron is laid a bed of concrete, which is leveled flush with the upper flanges of the I-beams. The concrete is made of Rosendale cement 1 part, gravel 2 parts, steam ashes 4 parts. No Portland cement is used in the composition. Above this bed, nailing strips are laid, with a concrete filling between them. The underside of the sheet iron floor is protected by a coating of lime mortar containing some cattle hair and asbestos, the corrugations in the iron floor serving to hold this ceiling in place. The lower flanges of the I-beams are also protected by this plaster coating held by a wire netting. Before the test the central panel of the floor was loaded with pig iron to 150 lbs. per sq. ft. The test was made in the same manner as all the other tests, which have recently been made by the Department: a hot fire being maintained in the building for five hours, which at the end of that time was quenched by a stream of water furnished by a fire engine and played upon the underside of the floor. The fire did not appear to damage the floor at all, even the plaster ceiling remaining in place. The stream of water tore the plaster from the iron, but did no other damage. The maximum deflection of the roof before the water was applied was less than 3 ins., and after cooling more than an inch of this deflection was recovered. After quenching the fire water was played on the top of the floor, and it was found to be water-tight.



The Bailey System of Fireproof Flooring.

RAILWAY CONSTRUCTION IN THE UNITED STATES IN 1896.

The year just passed has shown but little increase in the activity of railway construction, according to the records of two of our contemporaries, the mileage for 1896 being but little more than that of 1895. The "Railway Age" publishes a list of 163 lines, aggregating 1,802 miles, and its record for 1895 was 1,782 miles. The "Railroad Gazette" gives 131 lines, aggregating 1,692 miles, as the construction of 1896, and in 1895 its record was 1,428 miles. In our issue of Jan. 2, 1896, we gave a table showing the yearly mileage constructed since 1877; the final record for 1896 will be practically the same as that for 1895. The following table shows the total tracklaying in each state as given by the two papers. It will be noted that while the "Railroad Gazette" omits Kansas and gives Massachusetts 1 mile; the "Railway Age" gives Kansas 1.4 miles and omits Massachusetts.

Table of Railway Construction for 1896.

	"Railway Age."		"Railroad Gazette."	
	No. of lines.	No. of miles.	No. of lines.	No. of miles.
Alabama	6	37.0	5	35.5
Arkansas	5	69.7	3	85.5
California	8	186.8	5	177.1
Colorado	4	26.4	2	12.0
Delaware	1	8.0	1	8.0
Florida	7	79.0	5	60.0
Georgia	14	97.5	8	72.8
Illinois	4	58.5	5	58.2
Indian Territory	2	65.7	1	60.0
Indiana	3	17.3	3	16.8
Iowa	1	5.3	1	3.6
Kansas	1	1.4	..	....
Kentucky	3	15.0	3	32.5
Louisiana	5	154.1	3	149.0
Maine	5	21.8	4	19.6
Maryland	1	27.0	1	27.0
Massachusetts	..	....	1	1.0
Michigan	11	145.9	10	143.2
Minnesota	5	58.3	3	45.5
Mississippi	3	57.5	3	65.7
Missouri	2	11.5	2	15.0
Montana	1	56.0	1	56.0
New Jersey	4	10.5	5	8.0
New York	5	33.0	5	33.0
North Carolina	5	40.5	5	29.0
North Dakota	1	28.3	1	28.1
Ohio	5	63.9	5	63.1
Oklahoma	2	27.2	2	27.0
Oregon	3	12.5	1	5.2
Pennsylvania	15	90.4	8	71.1
South Carolina	1	10.5	1	10.5
Tennessee	3	28.0	2	23.2
Texas	8	82.8	5	79.2
Utah	2	38.0	2	38.0
Vermont	1	8.2	1	3.0
Virginia	2	9.0	2	18.5
Washington	3	14.5	3	15.5
West Virginia	4	19.0	7	25.0
Wisconsin	7	85.7	6	72.6
Total	163	1,802.4	131	1,692.7

IMPROVEMENTS IN THE RAILWAY MAIL SERVICE.

The annual report of the General Superintendent of the Railway Mail Service, Mr. Jas. E. White, which has just been issued, devotes especial attention to the improvements in the service and the reduction in the accidents and fatalities which have resulted from improved car construction and safer and better systems of lighting and heating. We quote the following from the report:

The improvement which has been made in car construction during the past few years still continues and, as a matter of fact, the improvements made in the construction of cars during the fiscal year ending June 30, 1896, have been greater than for any similar period since the organization of the service. A large number of railway post-office cars now in use are vestibuled and, in addition, are provided with all the modern improvements, such as light, heat, vestibuling, coupling, buffers, etc., and as a result they pass through accidents more successfully than before the Department exercised the right of directing how the framework should be constructed and the character of the improvements mentioned above. In proof of this statement, I wish to say that during the fiscal year ended June 30, 1895, there were 497 casual-

ties in which 7 clerks were killed, 50 seriously injured, and 128 slightly injured, as against 495 casualties in which 5 clerks were killed, 47 seriously injured, and 65 slightly injured during the fiscal year under review, a falling off in the number of killed and injured of 68—which is a very much better showing than we were able to make for any fiscal year since 1890.

Perhaps, independent of the improvements made in the construction of cars, so as to increase their carrying and resisting power, the greatest improvement has been made in the character of the light. Formerly nearly all the cars in the service were lighted with oil, different patterns of lamps being used, whereas at present 215 of the full railway post-offices in use are lighted with Pintsch gas and 13 with electricity. These two lights are regarded as not only the best for illuminating purposes, but also in the matter of the safety of the clerks and the mails in the event of accidents such as collisions, derailments, etc., occurring upon the trains upon which the clerks are assigned to duty. The advance made in this direction is exhibited by the following statement: The total number of full railway post-office cars in use is 778, the number heated with steam is 327, making a per cent. heated with steam of 42. The number lighted with compressed gas is 215, being 27% of the whole number of cars in use and held in reserve. In this work of improvement the Department has received the hearty co-operation of all important railway lines, and quite a large number of the companies who have not, up to the present, seen their way clear to the introduction of compressed gas, electricity and steam heating are considering the matter very carefully, and many of them have determined to adopt these features at an early date.

Another feature of much interest is the establishment of postal cars on cable and electric street railways in the large cities. There are now no less than 45 of these cars in service. Boston, Chicago, Brooklyn and St. Louis are the cities in which this service has been most developed. An interesting feature is the attempt to expedite the delivery of mail matter in large cities by having mail addressed not only to the street and number, but to the carrier route if it is delivered from the main post office, or to the branch post office if the party addressed is served by a carrier from one of these sub-stations. When mail is addressed in this way it can be sorted on the trains, and is then ready for delivery as soon as it arrives at its destination.

An exceedingly interesting table shows the rapid growth in importance of the railway mail service. In the fiscal year 1886 it handled 5,329,000,000 pieces, and in the fiscal year ending June 30, 1896, it handled 11,166,000,000 pieces, thus more than doubling its work in the decade. At the same time the accuracy of its work has shown a wonderful increase. In 1886 there were 4,228 pieces of mail correctly distributed to one error; in 1896 there were 9,843 pieces correctly distributed to one error.

During the year 26,355.71 miles of new and improved postal and apartment car service were added, the increased mileage being over 12,000 miles in excess of the average increase for any year since 1890. One of the most important of the new routes is that of the daily line of postal cars running through the Dominion of Canada between Buffalo and Detroit. This is the first instance of a United States railway post-office being operated in a foreign territory, and is significant of the harmonious relations existing between the postal authorities of the two countries.

ANCHOR ICE AT EVANSTON, ILL., is reported as having cut off the water for a few hours at the lake intake of the city water-works on Dec. 28.

FIVE TOPOGRAPHIC DRAFTSMEN, at salaries of $900, and a First Assistant in the Division of Chemistry, Department of Agriculture, at $1,800 per annum, are soon to be appointed, and examinations of applicants for the position will be held on Jan. 27. Persons desiring to compete should write to the U. S. Civil Service Commission, Washington, D. C., for an application blank and file their applications as soon as possible.

U. S. ASSISTANT ENGINEERS are to be hereafter selected by a competitive examination, and the Civil Service Commission, at Washington, D. C., having this branch of the public service in charge, has issued a call for an "examination of engineers," to commence on Jan. 12 and to be continued until further notice. One occasion for this call is the urgent need of such assistants on coast defence and harbor fortifications, in case of the passage of the bill of Congressman Mahaney, calling for an appropriation of $80,000,000 for coast defence, etc., and specifying that all those employed on such work shall be American citizens. The applicants for the position of Assistant Engineer are supposed to have a good knowledge of engineering construction and of hydrographic work, and the pay ranges from $100 to $300 per month. Notice will be given in due time of the places, other than Washington, where such examinations will be held, and detailed information can be obtained by addressing the U. S. Civil Service Commission.

THE STEVENS INSTITUTE OF TECHNOLOGY, Hoboken, N. J., will celebrate its 25th anniversary on the 18th and 19th of February next. The festivities will include a banquet at the Hotel Waldorf, New York city, to which representative engineers and technical educators will be invited, and a reception at Castle Point, Hoboken, the residence of Mrs. E. A. Stevens, widow of the founder of the Institute. On Feb. 19 the Institute will be open for inspection, and the apparatus in the various laboratories, together with the method of instruction, will be explained. An interesting feature of the exhibition will be a collection illustrating the work of the alumni during the 25 years, consisting of machinery, apparatus, drawings, etc. The Stevens Institute of Technology has always taken high rank among engineering schools, its specialty being the education of mechanical engineers. The first class entered in 1871, when the faculty consisted of Dr. Henry Morton, president, and eight professors. Dr. Morton still remains at the head of the Institute, and the faculty now numbers 22 professors and instructors. The number of graduates is 675, and the number of students in attendance during recent years has averaged about 250.

A JOINT OUTLET SEWER for Salem and Peabody, Mass., has been reported on by the Massachusetts State Board of Health. The sewage would be discharged into the sea, and pumping would be necessary. The carrying capacity of the sewer would be 38,000,000 gallons, if running two-thirds full, and 44,000,000 gallons if full. The estimated cost is $440,000. The expense of the investigation was $3,943. Mr. X. H. Goodnough is Chief Engineer of the board.

"THE INFLUENCE OF FORESTS ON IRRIGATION Problems" was the title of a paper written for the recent irrigation congress at Phoenix, Ariz., by Mr. B. E. Fernow, Chief of the Division of Forestry, U. S. Department of Agriculture. Mr. Fernow pointed out that it is quite as important to care for forests as to preserve them, meaning by preserve, prevent their entire removal by cutting. Forest fires, too great thinning out, the tramping down and solidifying of the soil by cattle and sheep, so as to make the soil less retentive of moisture, are all to be guarded against. About 17,000,000 acres of forest area has been reserved in the United States, but no means of caring for it has been provided.

THE USE OF METERS AT ALBANY, N. Y., although limited to the addition of but 1,700 in places suspected of waste, has greatly increased the pressure in the mains, improving both the domestic and fire service. It has also reduced the per capita consumption from 215 to 152 gallons per day. This information is taken from statements made by Mr. Geo. I. Bailey, Superintendent of Water-Works, in a recent newspaper interview. The introduction of meters has been vigorously fought, but a resort to the courts by their enemies was futile.

ASPHALT PAVING GUARANTEES in Missouri have been upheld by the State Supreme Court in a Jefferson City suit. In that city property owners pay for putting down new pavements, and the city for their maintenance. The plaintiffs in this case maintained that the agreement on the part of the contractors to keep the pavements in repair for five years increased the cost of the pavement to property owners by virtually making them assume the burden of street repairs. The court held that a five-year guarantee merely ensured the city of good work on the part of the contractors.

A HYDRAULIC DREDGE DECISION, says a San Francisco press dispatch, has been handed down by the United States Circuit Court of Appeals, at San Francisco, Cal., in the case of A. B. Bowers vs. Von Schmidt, approving the decision of the lower court, which was in favor of Mr. Bowers.

THE PARSONS STEAM TURBINE has been adapted to marine purposes by its inventor, Mr. Charles A. Parsons. A torpedo boat built and fitted with it, and named Turbania was tried on Dec. 15 near Newcastle-on-Tyne, and it is said to have attained a speed of 29.6 knots per hour over a measured mile. The boat is 100 ft. long, 9 ft. wide, and 42 tons displacement, and is provided with a water-tube boiler of 1,100 sq. ft. of heating surface, and 42 sq. ft. of grate, driven with forced blast on the closed stokehold system.

AN AUTOMATIC MACHINE, which at the same time makes paper bags, weighs sugar accurately, fills it into the bags, and seals them, it is said, is about to be used by Arbuckle Brothers, of Brooklyn, the leading coffee importers and roasters, who contemplate the building of a large sugar refinery, and entering into competition with the American Sugar Refining Co., commonly known as the Sugar Trust. The same machine has for some years been used by Arbuckle Brothers for packing coffee. It was invented by Mr. H. E. Smyser, of Philadelphia.

THE WAR AGAINST THE SMOKE NUISANCE is being urged in many Western and Southern cities at the present time. Memphis has passed a law against it, making the emission of dense smoke a misdemeanor, subject to a fine of $50, and making it the special duty of the chiefs of police and of the fire department to see to the enforcement of the ordinance. The city council of Nashville is also considering the passage of a similar ordinance. In the "Bulletin" of the Tennessee State Board of Health there is a letter from Mr. R. C. Graves, of Memphis, member of the board, describing a device for preventing smoke, which has been used in Memphis with good effect, which is so simple that any pipe fitter can make it, and on which there is no patent. The description is as follows: We put a 2-in. hole through the fire front, over or between the fire doors, inserting a pipe of the same size to admit the air, and then we put in a ⅜-in. pipe inside of the 2-in., through which we inject a steam jet against the lower part of the bridge wall just over the fire surface through a nozzle, in which are three holes about 1-16 in. in diameter, somewhat like a gas jet. This forms a spray over the fire, and draws in outside air in proper proportion through the 2-in. opening, and around the steam pipe, which together consumes the smoke, or a greater part of it, and this without great expense or use of steam. In fact, it is thought by some engineers that a gain rather than a loss is made, as the coal burns to better advantage.

A WATER-POWER PLANT at Menominee, Mich., is proposed by the Menominee River Boom Co., to utilize the power of the Chappee Rapids for developing electric power. There would be a fall of 40 ft. from the proposed dam.

THE TENNESSEE CENTENNIAL EXHIBITION, to be held at Nashville from May 1 until Oct. 30, promises to be a great success. President Cleveland has signed a bill appropriating $130,000 for the erection of a suitable building for the display of the United States Government exhibits, and the management announces that all the space in the several buildings allotted for exhibition purposes has been applied for, and a sifting process been begun to prevent the duplication of exhibits and avoid monotony in their character. It has been decided to give all space necessary for exhibits of the Southwest to the curtailment of that asked for by the North and East, in order that the exhibition shall be thoroughly representative of Southern resources and industries. Great efforts are being made to have all the buildings completed before April 1st, and it is expected that by the opening day the exhibition will be as complete as on any day during its progress, an achievement never accomplished at any previous exhibition.

THE BRUSSELS INTERNATIONAL EXPOSITION FOR 1897 is meeting with success in its applications for space from foreign governments. France has appropriated 841,000 francs for her display; England has secured 9,000 sq. m. of space, and Germany and other European States have signified their intention of being well represented. The Commission of the United States has issued a call, through the Department of State, to American manufacturers, and it is suggested that a proper display of our products may stimulate our commercial intercourse with European countries. A number of American exhibits have already been entered, including windmills and agricultural implements, fruits and wines from California, many bicycles and typewriting machines, American furniture, brewers' exhibits, etc.

GERMANY'S EXPORTS AND IMPORTS, says U. S. Consul Monaghan, of Chemnitz, now stands second to England only, and much exceed those of the United States. The comparative statement for 1895 is given as follows, exports and imports: England, $3,125,820,600; Germany, $1,926,729,000; United States, $1,524,770,000; and France, $1,366,167,600.

A HARBOR AT PORT ARTHUR, TEX., is being made the subject of elaborate memorials to congress by those interested. An appropriation of $1,000,000 is asked for the purpose of excavating a channel 120 ft. wide and 26 ft. deep from the head of Sabine Pass to the Neches River. The government has already expended $1,750,000, says the Philadelphia "Stockholder," in securing a depth of 25 ft. through Sabine Pass and in building jetties.. The chief pressure comes from Kansas City, which would be 767 miles, by rail, from the new port, as compared with 878 to New Orleans and 874 miles to Galveston. Sabine Pass is now claimed to be the deepest port on the Texas coast. The Kansas City, Pittsburg & Gulf Ry., completing the rail connection between Port Arthur and Kansas City, will probably be finished within the next three months, and traffic men want the seaport for Kansas City business. The question of deep water ports on the Texas coast was so thoroughly canvassed a few years ago when a board of U. S. engineers reported in favor of Galveston that the million dollars for Port Arthur are not likely to be forthcoming.